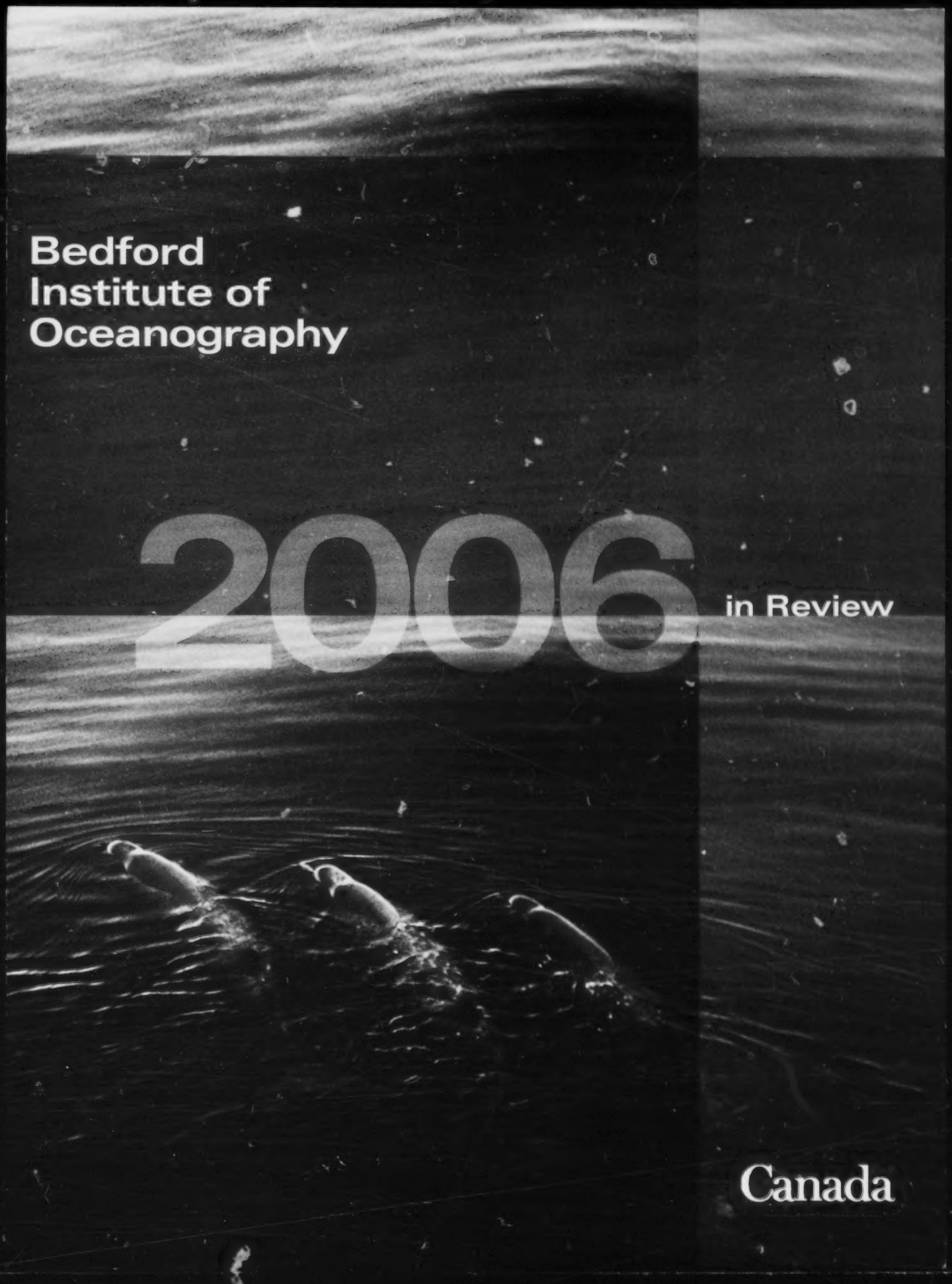
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Cover photo: Three endangered bottlenose whales. Photo© courtesy of Hal Whitehead Lab

Hal Whitehead's laboratory at Dalhousie University, Halifax, Nova Scotia, has been studying northern bottlenose whales in The Gully, along the edge of the Scotian Shelf, since 1988.

Back cover photo: The sea corn (Primnoa resedaeformi), left, and the bubblegum coral (Paragorgia arborea), two colour morphs on right, filter water at 950 m in the Coral Conservation Area in the Northeast Channel off southwestern Nova Scotia. Both species live in excess of hundreds of years. Photo courtesy of CMB-ROPOS 2006 Discovery Corridor

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INTRODUCTION

The Bedford Institute of Oceanography (BIO) is a major oceanographic research facility, established in 1962 by the Government of Canada and located in Dartmouth, Nova Scotia, on the shores of Bedford Basin. It has grown to become Canada's largest centre for ocean research. Scientists at BIO perform research mandated by the Canadian government to provide advice and support to government decision-making on a broad range of ocean issues including sovereignty, defence, environmental protection, health and safety, fisheries, and natural resources. Other activities such as environmental planning and oceans management are also carried out.

Fisheries and Oceans Canada (DFO) is represented by four divisions within its Science Branch including the Canadian Hydrographic Service (CHS), four divisions of the Oceans and Habitat Branch, the Aquaculture Coordination Office, and the Canadian Coast Guard Technical Services for technical and vessel support. Together they provide scientific knowledge and advice on issues related to climate, oceans, the environment, marine and diadromous fish, marine mammals, shellfish, and marine plants. As well, they are responsible for the fish habitat management protection program, environmental assessments, and oceans management and planning initiatives.

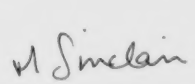
Natural Resources Canada (NRCan) is represented by the Geological Survey of Canada - Atlantic (GSC Atlantic), Canada's principal marine geoscience facility. Its scientific research expertise focuses on marine and petroleum geology, geophysics, geochemisty, and geotechnology. The GSC Atlantic is also the source of integrated knowledge and advice on Canada's coastal and offshore landmass.

The Route Survey Office of Maritime Forces Atlantic, Department of National Defence (DND), supports ocean surveillance activities. Surveys are conducted in areas of the sea floor of specific interest to DND in cooperation with CHS and the GSC Atlantic.

In support of the Canadian Shellfish Sanitation Program, the Shellfish Section of Environment Canada (EC) conducts sanitary and water quality surveys and analyzes the samples at the microbiology laboratory at BIO.

Altogether, approximately 650 scientists, engineers, technicians, managers, support staff, and contractors from a variety of disciplines work at BIO.

This review highlights some of the ongoing research activities at the Institute as well as some of the activities dealing with the management of ocean uses.



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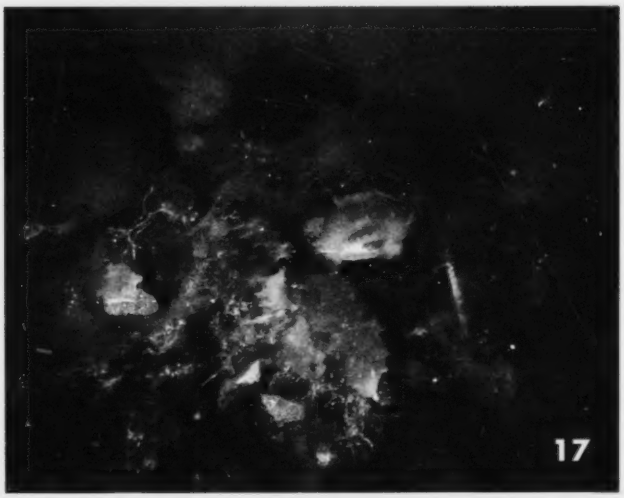

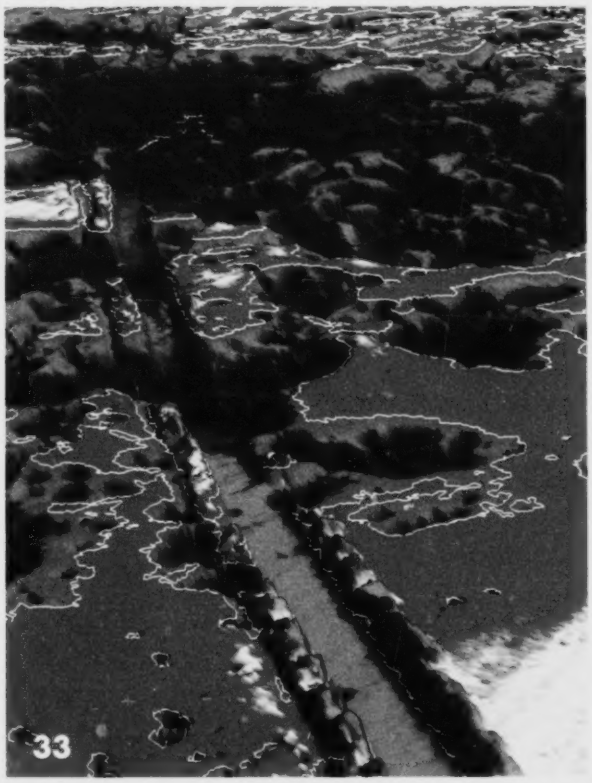

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FEATURE ARTICLE

Putting Integrated Oceans and Coastal Management into Practice: Collaborative Progress on Implementation of Canada's *Oceans Act*

Heather Breeze, Scott Coffen-Smout, Jason Naug, Paul Keizer, and Dick Pickrill†*
Oceans and Coastal Management Division, Oceans and Habitat Branch, DFO Maritimes Region

Effective ocean resource management that balances ocean development and marine environmental health is vital to Canada's vision to be a global leader in ocean management, ocean science, and sustainable ocean development. The foundation of our oceans policy and programs is Canada's *Oceans Act* (1997). Under the Act, Fisheries and Oceans Canada (DFO) is charged with leading and facilitating the development and implementation of a national oceans management strategy, integrated management plans for all of Canada's marine waters, and a national system of Marine Protected Areas (MPAs).

Canada's Oceans Strategy (2002) affirmed integrated management as a priority and defined Canada's policy for management of estuarine and marine ecosystems to meet the objectives of the Act. The policy is based on the premise that oceans must be managed as a collaborative effort among governments and stakeholders. Principles of sustainable development, the precautionary approach (a commitment to err on the side of caution), and the integrated management of all activities in estuaries and coastal and marine waters form the foundation of the policy.

The Oceans Action Plan (OAP) was developed in 2004–2005, as a cooperative effort by 18 federal departments and agencies, to guide government-wide action to deliver Canada's Oceans Strategy. The OAP is structured as four interconnected pillars:

1) International Leadership, Sovereignty and Security;
2) Integrated Oceans Management for Sustainable Development;
3) Health of the Oceans; and
4) Ocean Science and Technology.

OAP Phase I implementation is occurring during 2005–2007, with incremental funding of $28 million. The federal departments responsible for delivering the Integrated Oceans Management Pillar agreed to focus on five priority areas: the Beaufort Sea, Pacific North Coast, Gulf of St. Lawrence, Scotian Shelf, and Placentia Bay/Grand Banks.

This article focuses on the activities of DFO and NRCan at BIO towards implementation of Canada's 2005 Oceans Action Plan.

SEAFLOOR MAPPING IN SUPPORT OF INTEGRATED OCEANS MANAGEMENT

The management of Canada's offshore lands has been constrained by inadequate maps. NRCan, in partnership with the Canadian Hydrographic Service (CHS) of DFO, was charged with producing seafloor maps to support the development and implementation of management plans in the five OAP priority areas. The mapping

Map is an "A" Series interpreted surficial geology map of the continental slope south of Sable Island, offshore Nova Scotia. The sediment type is draped over the multibeam bathymetry. The edge of the continental shelf is at the top of the map, incised by Logan Canyons infilled with coarse sandy sediments (brown) extending downslope and out onto the continental rise. Sediments on the interfluves are muddy (blue and red).

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† Marine Environmental Geoscience, Natural Resources Canada

Google Earth Screen grab is of NRCan multibeam data holdings off eastern Canada: One hundred and fifty data sets have been made accessible via the Internet at *http://gdr.nrcan.gc.ca/index_e.php* (click on Canadian Marine Multibeam Bathymetric Data in the Marine Geoscience section). These very high-resolution datasets of the seabed bathymetry can also be viewed in Web Mapping Service (WMS) such as Dapple (*http://dapple.geosoft.com*) and Google Earth (*http://earth.google.com*).

program is being operated by NRCan at BIO but delivered nationally. New multibeam seafloor mapping technology, combined with traditional ground truth surveys, has enabled the production of high-resolution maps of the seabed (equivalent to onshore aerial photography), revolutionizing our understanding of the marine environment and laying the foundation for implementing integrated oceans management. In 2005, NRCan developed a new national map series, incorporating four layers: sun-illuminated seafloor topography, backscatter strength (or indication of seafloor texture), surficial geology, and benthic habitat. Maps are now being produced at three scales: 1:10,000 in coastal waters, 1:50,000 on the continental shelf, and 1:100,000 on the slope.

Over the last two years, surveys have been active in all three of Canada's oceans. Surveys have been completed in smaller areas, such as Placentia Bay, Newfoundland and Labrador (NL), but are ongoing in the larger Large Ocean Management Areas (LOMAs) such as the Pacific North Coast. The Beaufort Sea has proven particularly challenging, where a short field season and ice-covered shallow waters have forced the adoption of a corridor approach: mapping small representative areas from the coast out across the continental shelf. Since the introduction of multibeam technology over a decade ago, more than 140,000 km^2 have been surveyed, an area larger than the land of the three Maritime Provinces (New Brunswick, Nova Scotia, and Prince Edward Island), leading to the production of more than 130 map sheets. While formal map products will remain the principal outlet to distribute the processed information, increasingly, web access will make the products and data available to the general public.

Through the Oceans Action Plan, the benefits of mapping to conservation and sustainable resource development are already being demonstrated. Map products have been used to avoid and minimize conflicts of use in the ocean space and to underpin conservation measures. For example, map products have helped in:

- Identifying four vulnerable sponge reefs in the Queen Charlotte Basin, leading to conservation through closure to trawling;
- The Royal Society review of the moratorium on hydrocarbon exploration offshore British Columbia;
- Delivering foundation maps to underpin regional maritime planning in Placentia Bay, NL;
- Developing integrated management in LOMAs, such as the Eastern Scotian Shelf Integrated Management (ESSIM);
- Developing a management plan for the Bras d'Or Lakes;
- Designating Marine Protected Areas (MPAs) such as The Gully.

The latter three are OAP activities led by DFO at BIO.

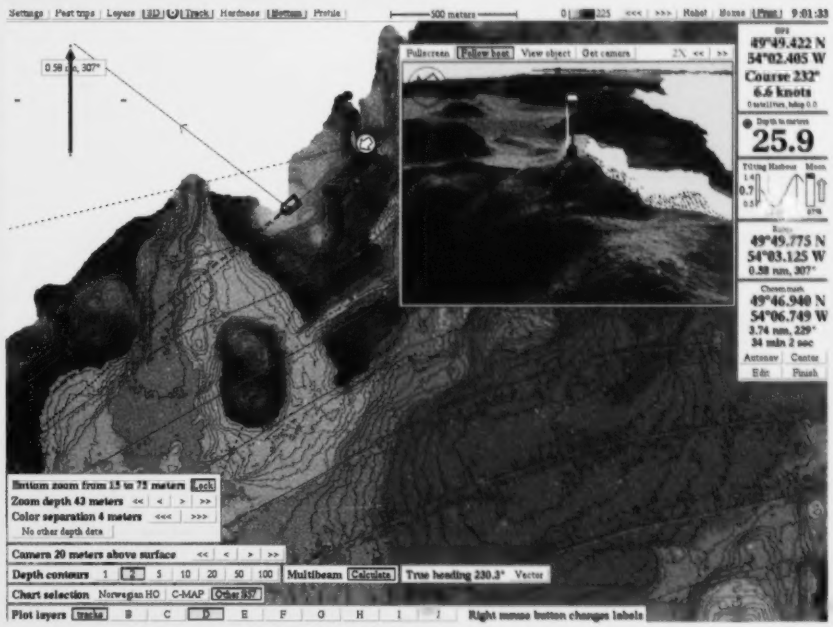
Canada is not alone in recognizing the benefits of seafloor mapping in management and conservation of offshore resources. Several other countries have initiated national mapping programs to underpin sustainable ocean management policies. NRCan's vision in the next decade is to deliver a national mapping strategy to complete the mapping of Canada's offshore lands.

INTEGRATED MANAGEMENT PLANNING

The Eastern Scotian Shelf Integrated Management Initiative

The Scotian Shelf was identified as a priority area for integrated management planning in OAP Phase I. The ESSIM Initiative falls under the OAP pillar "Integrated Oceans Management for Sustainable Development" and is a collaborative ocean-planning process led and facilitated by DFO Maritimes Region. It was announced by the Minister of Fisheries and Oceans in December 1998, following the recommendation from the Sable Gully Conservation Strategy that integrated management approaches be applied to the offshore area around the Sable Gully Area of Interest (AOI) then being developed under DFO's MPA Program. In contrast to traditional sector-based management, which addresses individual industries or activities on a case-by-case basis, the ESSIM planning process considers the ecosystem and all of its users comprehensively. The Initiative brings regulatory authorities from all levels of government together with a wide array of ocean stakeholders to work collaboratively. This allows for a more coordinated, comprehensive, and inclusive management approach and helps to prevent conflict among different ocean users and between humans and the environment. The primary aim of the ESSIM Initiative is to develop and implement an Integrated Ocean Management Plan that will guide the sustainable use, conservation, and management of this large marine region.

In February 2005, the ESSIM Planning Office, housed in the Oceans and Coastal Management Division (OCMD) at BIO, presented a draft Integrated Ocean Management Plan to stakeholders for review at the 3rd ESSIM Forum Workshop. Based on the generally positive feedback, the Planning Office launched a broad public review of the draft plan over the spring, summer, and fall of 2005. Following this review, a multi-stakeholder advisory group, known as the Stakeholder Advisory Council (SAC), representing all major ocean sectors including governments, oil and gas, commercial fisheries, transportation, telecommunications, conservation groups, community groups, academic and private sector research, tourism, and aboriginal groups in the planning area, was assembled to work with the Planning Office to revise the draft plan. Based on the feedback and recommendations received through the public, stakeholder, and government review processes, the Planning Office prepared and released a final draft of the Integrated Ocean



This is an example of importing multibeam imagery directly into an electronic navigation system for commercial applications. In this CHS survey off Newfoundland, the hydrographer is not only navigating over the imagery, he is actually building the image as he surveys. The insert displays a 3D perspective looking forward from the ship.

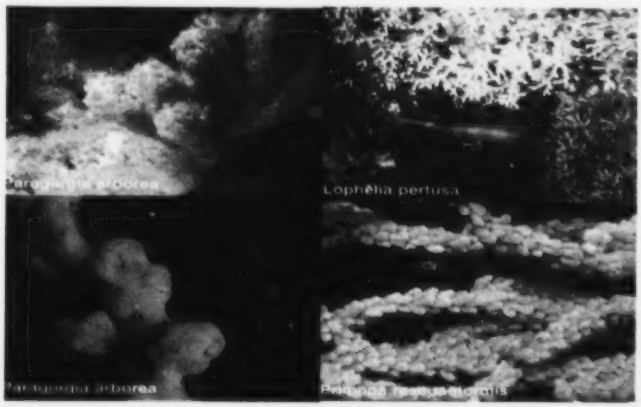
Map products are also providing increased certainty for industry and are being used to foster growth in the maritime economy. For example, economic competitiveness and management practices in the fishing industry have been improved, such as in the Nova Scotia scallop fishery where the maps are used to improve stock assessment and to guide less destructive, more targeted fishing. As well, hydrocarbon development has been facilitated by reducing risks from offshore hazards such as landslides, and improving design criteria for offshore structures by understanding seabed processes such as ice scouring (e.g., Beaufort Sea pipelines).

Management Plan in July 2006 for public comment.

The SAC will continue to have a core role in the development and implementation of the Integrated Ocean Management Plan and is working in partnership with the Planning Office and the intergovernmental Regional Committee on Ocean Management (RCOM) to move the plan forward. The RCOM is an intergovernmental body of federal and provincial authorities to provide senior-level guidance and coordination for regional ocean management activities. One of the key functions of the RCOM will be to facilitate approval of the ESSIM Plan by relevant government authorities. Program level support to the RCOM is provided by the Federal-Provincial ESSIM Working Group. Through the SAC and the RCOM processes, stakeholders and government departments reviewed the plan. Its acceptance and endorsement are anticipated, such that it will be formally recognized as Canada's first Integrated Ocean Management Plan under the *Oceans Act*.

Coral Conservation Plan

As part of the ESSIM initiative, a Coral Conservation Plan was developed. For the past several years, DFO Maritimes has carried out cold-water coral research and engaged in discussion on conservation requirements with other government departments, the fishing industry, and other oceans-related interest groups. In 2002 and 2004, DFO Maritimes established fisheries closures in two areas to protect high concentrations and rare occurrences of corals in the Northeast Channel and the Laurentian Channel Lophelia coral conservation areas. Other organizations and researchers also engaged in research and activities related to cold-water corals. A Coral Conservation Plan was needed to document these activities and to provide direction for future conservation, management, and research. In October 2004, DFO hosted a workshop to identify key issues and a draft plan was released for public review in February 2005. Comments on the draft were accepted and the revised plan was released in April 2006.



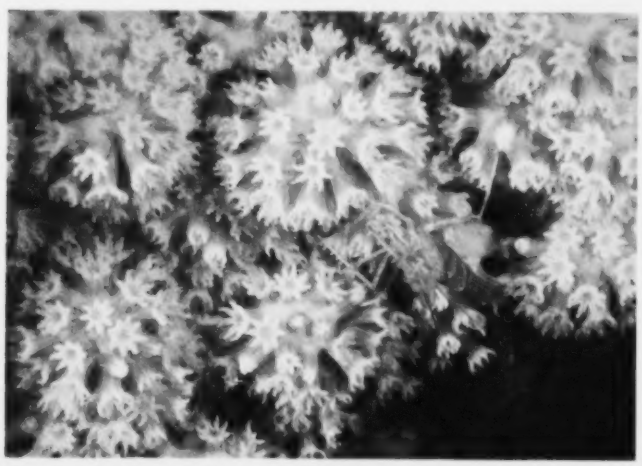
Deep-sea corals found on the Scotian Shelf Slope

The Coral Conservation Plan is related to two pillars of the OAP: "Integrated Oceans Management for Sustainable Development" and "Health of the Oceans". The development of a Coral Conservation Plan that includes the Scotian Shelf in its scope reflects the priority of region-wide coral protection in integrated ocean management and planning. Phase I of the OAP has resulted in funding for some coral management, conservation, and research. Future funding for coral conservation, management, and research will be based on the priorities of the plan.

Bras d'Or Lakes Coastal Management Area

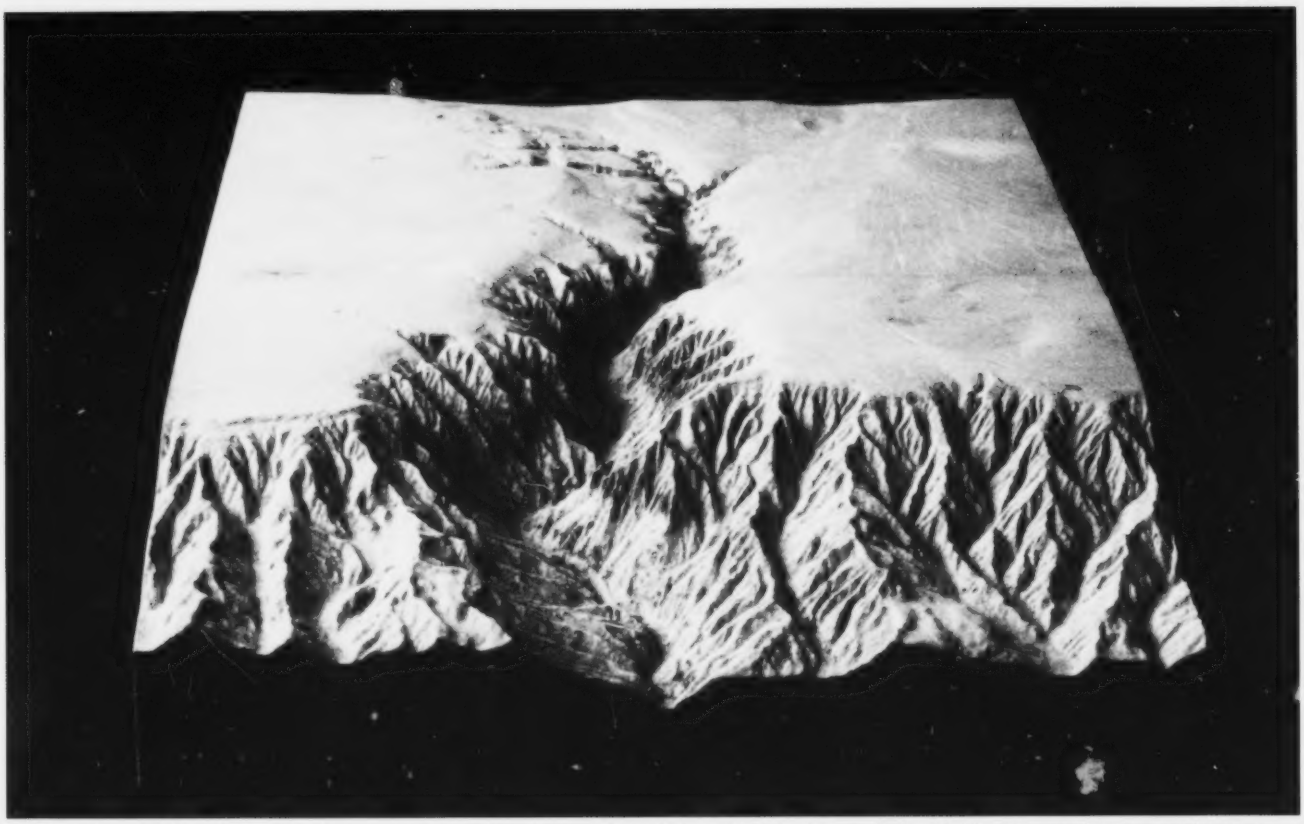
The Bras d'Or Collaborative Environmental Planning Initiative (CEPI) is the first Coastal Management Area under the OAP. Since 2003, a broad partnership of federal, provincial, municipal, and First Nations governments has been working with local NGOs, academics, industry, and community members toward the development of an overall management plan for the Bras d'Or Lakes and watershed lands. Initial efforts included two large workshops to discuss this undertaking and to secure the wide range of support required for its success. The first workshop was for government and First Nations to agree on the plan's scope, while the second sought feedback from the broader community. During these workshops, held in the First Nations community of Wycocomagh, more than 250 people reached agreement on the need and approach to develop this plan, and that the Unama'ki Institute of Natural Resources, representing the five First Nation communities of Cape Breton, should play a coordinating role, with support provided by the federal and provincial governments.

This work complements efforts in the Bras d'Or area by scientists from DFO, NRCan, and the Eskasoni Fish and Wildlife Commission under the Science for the Integrated Management of the Bras d'Or Lakes (SIMBOL) program. Through a range of scientific programs, SIMBOL has been providing a better understanding of this unique and important ecosystem. The research forms the foundation of the



Close-up of the bubblegum coral (*Paragorgia arborea*) at 950 m in the Coral Conservation Area in the Northeast Channel off SW Nova Scotia

Workshop to develop a management plan for the Bras d'Or Lakes and watershed — photo courtesy of George Paul



Solid terrain model of The Gully submarine canyon and area based on multibeam bathymetric data: the area depicted is 90 x 64 km, or 5,760 square kilometres (model size: 50 x 35 x 10 cm).

management plan and supports an ecosystem-based approach to the management of the Bras d'Or.

The overall goal of the Bras d'Or CEPI is to develop a comprehensive management plan and foster its implementation by government and other stakeholders. A framework has been prepared to develop a plan at the scale of the entire watershed planning area as well as at each sub-watershed area, to incorporate general and site-specific requirements. A detailed management plan has been developed for one of the twelve sub-watersheds. This undertaking, in partnership with a local community group, identifies priorities for action based on scientific assessments and extensive community input. To support these planning efforts, an Ecosystem Overview and Assessment Report was completed for the Bras d'Or that summarizes marine and terrestrial ecology, human uses, and First Nations traditional ecological knowledge. The report provides an overview of the entire ecosystem and a foundation for the State of the Bras d'Or Report that is underway to assess the health of the Bras d'Or using a range of specific indicators.

Sunset over Lake Bras d'Or — photo courtesy of Rick Dennis

MARINE PROTECTED AREA PLANNING AND IMPLEMENTATION

The Gully MPA Management Plan and The Gully Advisory Committee

In May 2004, The Gully MPA became the first officially designated MPA in the Maritimes Region. This designation followed several years of research, assessment, and consultation with stakeholders. The MPA protects the diverse habitats of a large submarine canyon and its related biological communities, including an endangered population of northern bottlenose whales.

The draft Gully Management Plan was developed to support the MPA Regulations and provide guidance to DFO, other regulators, marine users, and the public on protecting this important ecosystem and managing the area around it. The plan provides a multi-year framework that includes an overall vision and objectives for The Gully and priorities for its conservation. It also includes a description of the regulations, boundaries and zones, and specific actions to protect The Gully ecosystem. The draft was released in spring 2006 for public review and a final plan is expected shortly.

The Gully Advisory Committee provides advice to DFO on the

management of the MPA.

The Committee includes representatives from federal and provincial governments, First Nations, commercial industries, conservation organizations, and academic institutions. Initially set up as an informal body to provide information on The Gully and the MPA status, it has since provided feedback on the initial regulations for the MPA, helped to develop the management plan, and transformed itself into a more formal committee with consistent membership.

Musquash Estuary Marine Protected Area

The Musquash Estuary is located approximately 20 km west of Saint John, New Brunswick. With its rich fish and wildlife habitat and high productivity, it is one of the last relatively ecologically intact estuaries in the Bay of Fundy. The Musquash estuary is 16.3 km long and is composed of a large outer harbour and an extensive salt marsh and tidal flat totaling approximately 2,700 hectares. Of this, 773 hectares are Class 1 saltmarsh, deemed the highest value to wildlife. The estuary is home to such flora and fauna as saltmarsh cordgrass, saltmarsh hay, Indian sweetgrass, Bristle worm, periwinkle, dog whelk, limpet, Piping plover, common snipe, purple sandpiper, and osprey.

Musquash has long been of interest for conservation, and in 2000 was formally identified as an AOI for protection under Canada's *Oceans Act*. Community, environmental, and government interests formed the Musquash Estuary Advisory Committee in 2002 to provide ongoing advice on the MPA establishment process, conservation planning, and implementation of a management plan. A number of studies and research efforts have been undertaken during the assessment stage of the MPA process, including those relating to both ecological and socio-economic aspects. Regulations for the MPA were drafted and published for public comment in the *Canada Gazette 1* in June 2005. The regulations reinforce, augment, and formalize interim protection policies and measures required when designating an MPA under the *Oceans Act*. These regulations are aimed at protecting the estuary's ecological integrity and include the delineation of these management zones. Comments on the draft regulations have been addressed, an agreement with the province of New Brunswick to manage the Musquash Estuary and surrounding area has been developed, and the process of designation is expected to be completed in early 2007. To guide its management, a Musquash Estuary Marine Protected Area Management Plan has been drafted.

(Editor's Note: The Musquash Estuary was officially designated as Canada's sixth MPA on March 7, 2007.)

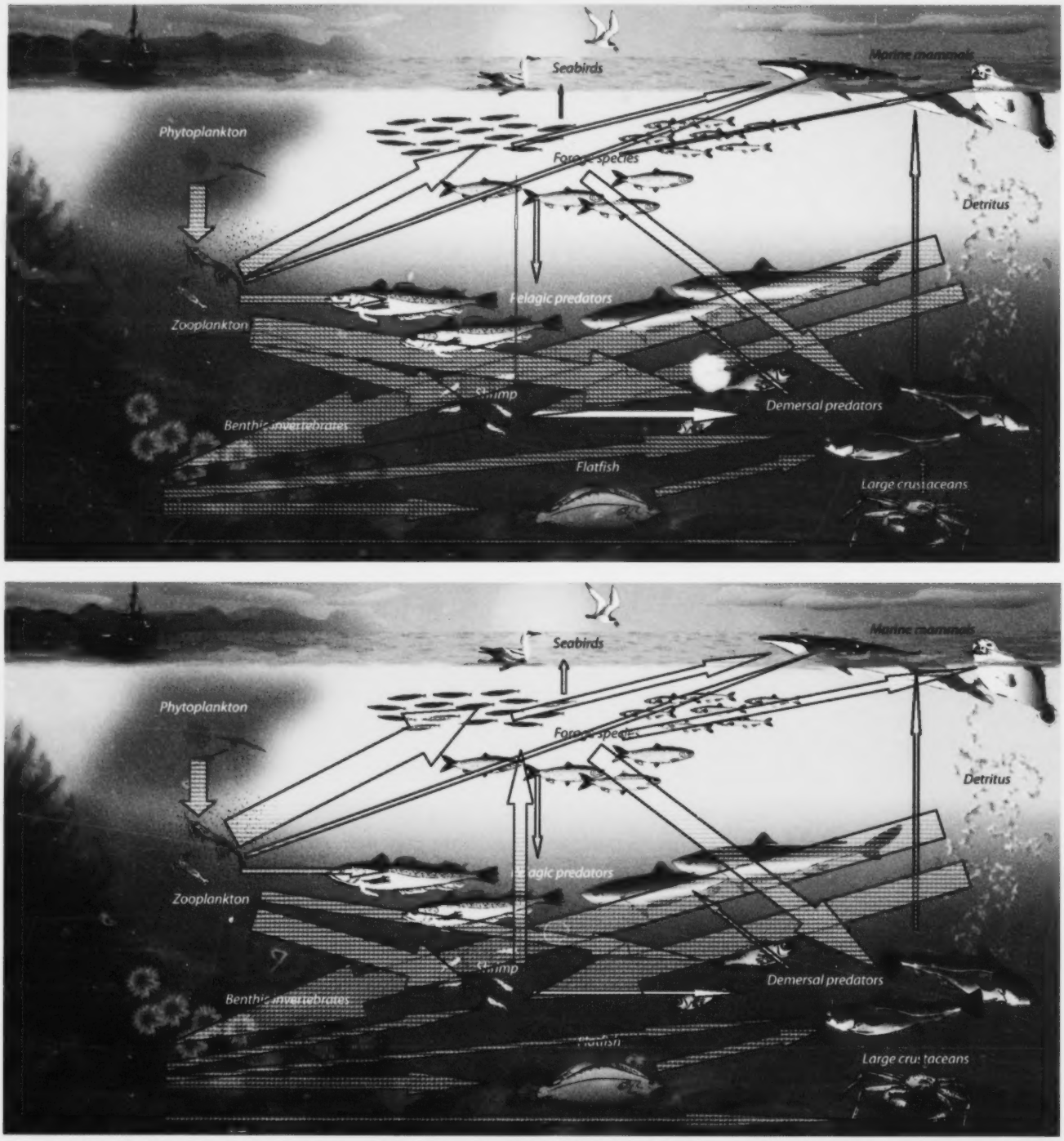
The Musquash Estuary — photos courtesy of David Thompson

KNOWLEDGE, TOOLS, AND PROGRAMS IN SUPPORT OF OCEAN MANAGEMENT AND THE PLANNING PROCESS

Science

Essential for effective management of human activities in our marine waters is scientific knowledge of the structure and function of marine ecosystems. Providing this information is a major challenge for marine science globally where comprehensive studies of marine ecosystem structure and function are rare. For the ESSIM Initiative, for example, the first task for scientists was to assess the present state of knowledge. This meant conducting a comprehensive review of existing literature and data for the area and extracting the relevant information. This information provided the basis for an ecosystem overview. Through a process of modelling, workshops, and scientific peer review, the ecosystem overview forms the basis for an ecosystem assessment, a description of how we believe the ecosystem is structured, and how it functions. Like all marine ecosystems, the structure and function of the Eastern Scotian Shelf ecosystem is highly complex and there is much uncertainty associated with many of its important components. In recent years, major changes have been observed in its structure and function, but it is unknown how much of this change is the result of human activities or natural ocean climate variability.

To provide focus for future research and monitoring activity, the concepts of ecologically and biologically significant areas (EBSAs) and ecologically significant species and community properties (ESSCPs) have been advanced. The premise is that in a marine ecosystem there



Figures demonstrate changes in the ecosystem, by describing the output from the ECOPATH model for ESSIM for 1980 (top) and 1990 (bottom). The arrows indicate the direction and magnitude of energy or carbon flows in the ecosystem. In both cases, primary production, e.g., phytoplankton, is consumed by zooplankton. Of particular note, however, is the change in the fate of secondary productivity (zooplankton). In the 1980s, zooplankton was predominantly consumed by groundfish, e.g., cod, but by the 1990s this production was largely being consumed by pelagic forage fish, e.g., herring. (Pelagic describes fish that occupy the upper levels of the water column.) (Graphic from St. Lawrence Observatory Internet Portal - Dept. Fisheries and Oceans Canada [http://www.gc.ca].)*

are identifiable areas, species, and communities, and properties that are key to their structure and function. Focusing attention on these will offer the best opportunity for the development of management actions that will ensure the sustainability of human activities.

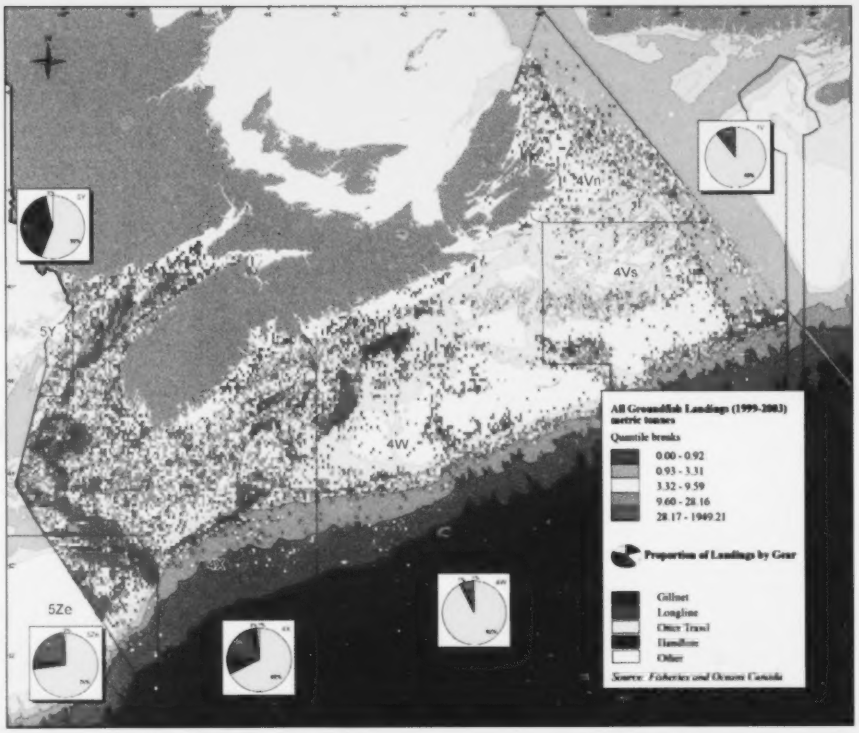
Marine areas such as ESSIM are vast with only limited information on habitat and species; therefore, extrapolation of information through the use of trawl survey data, numeric modelling, and other sources is essential to providing scientific advice. For the ESSIM area, information describing habitat is being collated and will be used to develop geospatial models to evaluate the EBSA

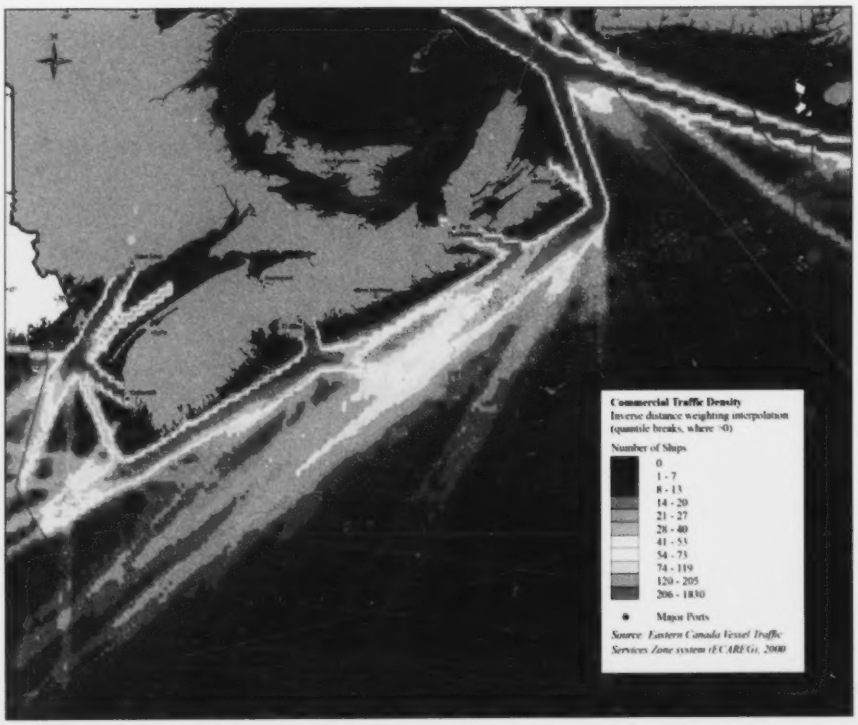
criteria for this area. This largely objective determination will be compared to the outcome of an exercise in January 2006 where individuals with knowledge of the area were asked to identify areas meeting the EBSA criteria based on scientific expert opinion (DFO, 2006). As well, traditional knowledge is being collected through surveys with aboriginals and local fishers. This ecological knowledge will be incorporated to support and further refine the scientific expert opinion.

The overall goal of a healthy ecosystem can be achieved only through the integration of all conservation objectives, as well as those for sustainable human use (i.e., social, cultural, and economic well-being). Ongoing monitoring and regular review of management plans and actions will be used to measure and evaluate progress on management objectives and to identify alterations and revisions required to address changing conditions or improved levels of knowledge—all part of the adaptive management framework in ocean management and planning. National criteria for identifying EBSAs have been developed through a series of national workshops (DFO 2004). Similar work on ESSCPs is in progress with the initial national workshop having been held in September 2006 and the criteria for identifying ESSCPs should be available soon.

The Scotian Shelf: An Atlas of Human Activities

For several years the ESSIM Planning Office has been collecting information on the location of human activities and management boundaries. *The Scotian Shelf: An Atlas of Human Activities* was prepared by the Planning Office to show the extent of human activities on the Scotian Shelf and their related management boundaries. Managing multiple activities is a major theme in the draft Integrated Ocean Management Plan. By providing information on the extent and intensity of a broad range of activities, it is hoped that all those involved with the ESSIM Initiative will gain a better understanding of human activities in the offshore. Also, the atlas has been popular with various stakeholders, including fisheries managers, academics, and consultants.



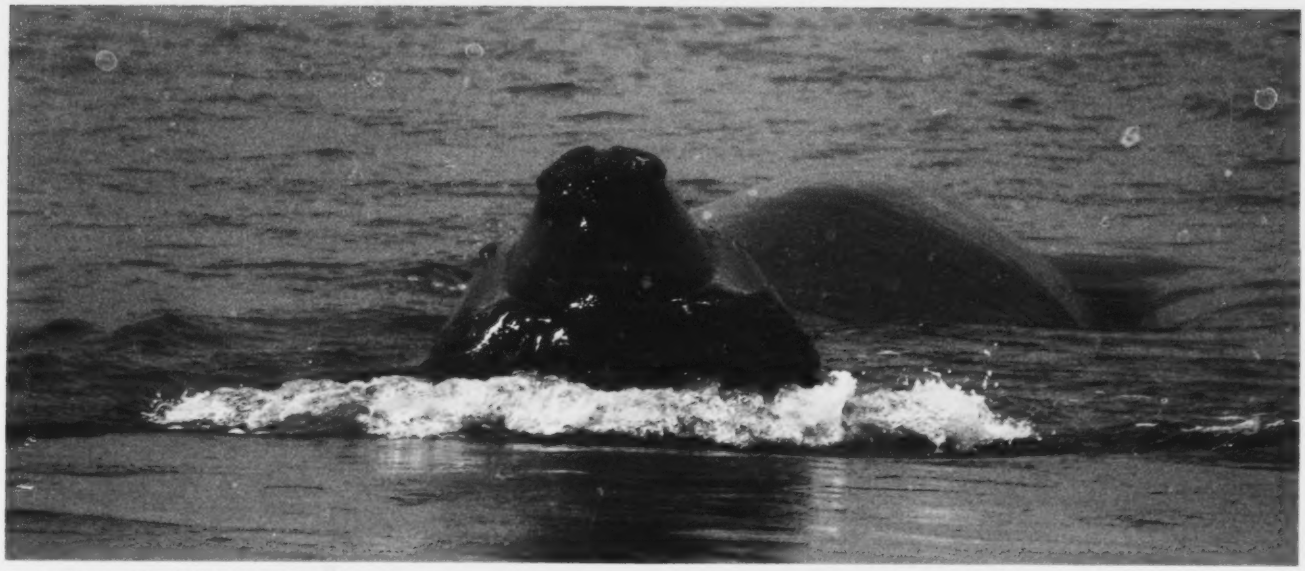


From the Atlas of Human Activities: Groundfish Landings (1999-2003) above and Commercial Shipping Traffic Density (2000), below

GIS for Management of the Oceans (GISMO)

One of the purposes for developing the Atlas of Human Activities was to collect and verify data on human uses and use this data to develop a decision-support tool for oceans management. With this tool, marine planners and other decision-makers would be able to identify human activities and ecological features for any particular area in the region.

Responding to the need for a decision-support tool, staff in OCMD developed GIS (Geographic Information System) for



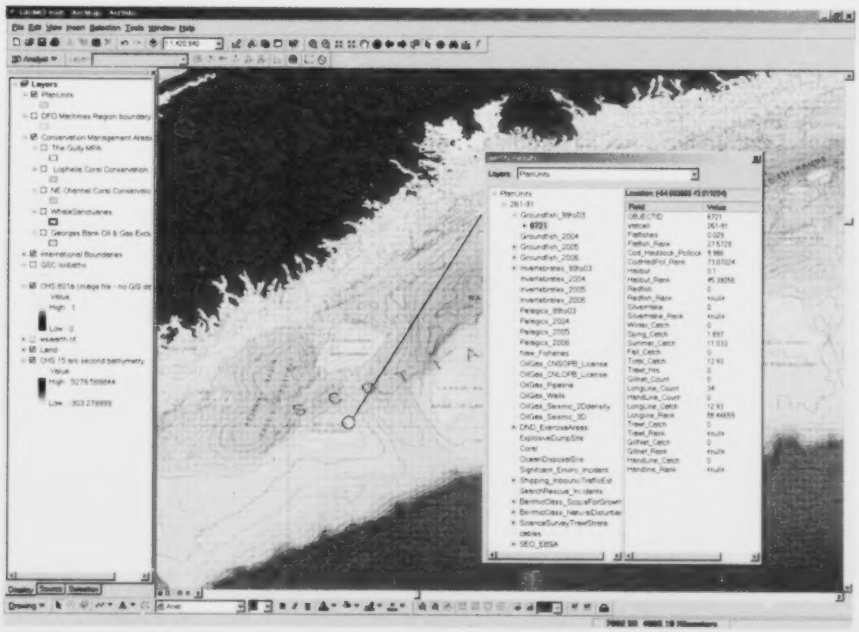
The endangered North Atlantic right whale

Management of the Oceans (GISMO)—a database of spatial information about human activities and biological/ecological features in the offshore areas of the Maritimes Region. These data are most easily accessed by using an ArcGIS map document created for users to view and query the data. Together the database and the map document operate as the tool: GISMO. Currently, most of the data in GISMO are related to human activities and management boundaries; however, more data on ecological features will be added over time.

Creating a "Recognized Fishing Picture" in Marine Conservation Areas

The OCMD and the Population Ecology Division (PED) of DFO are undertaking a joint program to build and maintain a computer application that can be used to monitor fishing activity in several marine conservation areas off Nova Scotia. The "recognized fishing picture" is built using data from several different monitoring and information sources maintained by DFO and was developed using the PED's Virtual Data Centre, which provides access to the information sources.

Currently, the program is being used to monitor fishing activity in the following areas: The Gully MPA, the Northeast Channel Coral Conservation Area, the Lophelia Coral Conservation Area, the Roseway Basin Marine Mammal Conservation Area, and the Grand Manan Basin Marine Mammal Conservation Area. A variety of exclusions and restrictions on commercial fishing exist in The Gully MPA and the two coral conservation areas. Although no regulatory restrictions are in place for the marine mammal conservation areas, the program is being used to monitor and describe fishing activity to support planning efforts aimed at the recovery of the endangered North Atlantic right whale.



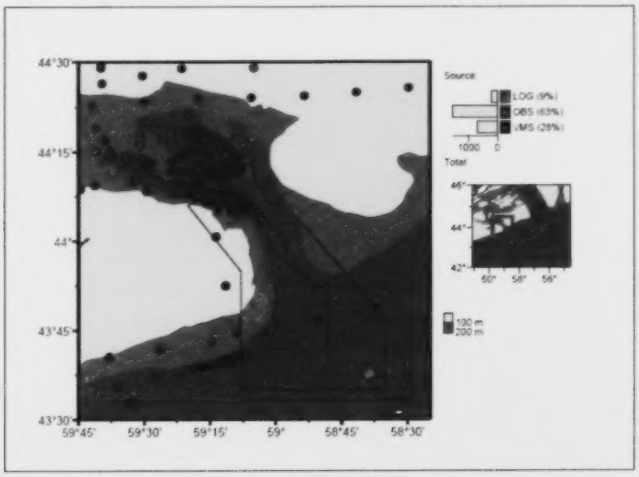
GISMO computer screen grab

CONCLUSION

Significant progress has been achieved in putting integrated oceans and coastal management into practice in Atlantic Canada through the combined efforts of DFO and NRCan staff at BIO. This work has been supported for 2005-2007 with funding under Phase I of the Oceans Action Plan. Ecosystem-based tools and frameworks have been established for integrated approaches in offshore and coastal areas, providing opportunities to show practical implementation and the benefits and strengths of interdepartmental collaboration. Efforts to develop Large Ocean

North Atlantic right whale

Management Areas in Atlantic Canada are of interest to other areas in Canada and internationally, and as the integrated management process evolves, continuous learning will yield adaptations to get it right.



Recognized Fishing Picture: a typical view of longline fishing activity over a 60-day period in The Gully Marine Protected Area, sorted by information source (logbook, at-sea observer, and Vessel Monitoring System [VMS])

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SCIENCE ACTIVITIES

Mapping Nearshore Marine Habitats with Video and Sidescan

Herb Vandermeulen and Sean Steller

The shallow waters along our marine shores are a national treasure. Known as the nearshore, this swath of water extending from the high-tide mark to a depth of about 10 m is an incredibly dynamic, diverse space ruled by the harsh environmental transition between land and sea. In some cases, this transition is buffered by hundreds of metres of salt marsh and mud flats in a gently sloping brackish estuary; in others, the transition is abrupt, such as where stony cliffs plunge directly into the sea.

The societal and ecological value of these nearshore waters cannot be overestimated. All marine vessel transport must transit this zone via dredged channels, jetties, docks, and other engineered structures. Natural harbours such as Halifax are an economic blessing because the nearshore is already configured in a way which is conducive to water-based transport. Tourism flourishes when nearshore waters are pristine and retain their scenic value. Recreational opportunities abound as swimmers, sailors, SCUBA divers, and beachcombers each explore different facets of the nearshore environment. Many commercial species are harvested directly from these waters (e.g., lobsters, oysters, mussels) or spend some time there growing up or spawning. Sometimes human activities can be to the detriment of the area, when they damage habitat and put at risk the species who live there.

Figure 1 Early days with electronics boxes in the Boston Whaler: everything is exposed to the elements.

DFO has legislative and regulatory obligations to manage nearshore marine habitats through Canada's *Fisheries Act* and *Oceans Act*. This management of the nearshore relies heavily upon science support, as many aspects of nearshore ecosystem structure and function are poorly understood and/or very site specific.

The predominant questions asked of scientists about the nearshore are: What does the bottom look like (sand, rock, eelgrass, seaweed, etc.)? Which organisms are using that space? How are the organisms distributed in the space?

Since 2003, the Ecosystem Research Division (ERD) at BIO has been working to address the first question; the other questions will be examined as the nearshore habitat project matures.

"What does the bottom look like?" seems a trivial question. One might think that simply putting on a diving mask and looking under water would yield the answer. However, management issues in the nearshore tend to be bay wide in scale (tens of kilometres). It is logistically difficult, time consuming, and expensive to send a team of SCUBA divers to map the bottom of a 20-km stretch of shoreline from high tide down to 10 m. More remote observation methods are required.

Aerial photography, Compact Airborne Spectrographic Imager (CASI), Light Detection and Ranging (LiDAR), and even satellite imagery work well at a scale of tens of kilometres, but their ability to penetrate turbid nearshore waters (particularly from 5 to 10 m deep) is poor. The authors have yet to see any aerial remote observation systems that can map nearshore bottoms accurately without extensive (and expensive) ground truthing and image analysis.

We decided to focus on echo-sounder and video methods to map nearshore bottoms at the bay-wide scale. Both methods are georeferenced (latitude and longitude) via differential Global Positioning System (dGPS) to provide sub-metre precision and an accuracy of 2 to 3 m. Underwater video has a long history of use, and the equipment is relatively inexpensive.

During the first two years of the program, a small (15-foot) Boston Whaler (Figure 1) was the vessel platform. All electronics were housed in vented waterproof boxes and controlled by waterproof switches and computer mice and keyboards. Recently, a 22-foot wheelhouse vessel

Figure 2 This wheelhouse vessel, now used in the nearshore habitat program, provides dry space to secure gear.

(Figure 2) was obtained, and the electronics (including two notebook computers for data acquisition) are now mounted on shelves or at the helm. Deep-cycle batteries and gel packs are used for onboard electrical power, with AC power via inverters.

An inexpensive high frequency sidescan system, the Imagenex™ SportScan, was purchased. This unit is run at 800 kHz at a swath width of 30 m. The sidescan towfish is mounted directly to the hull of the vessel. The data file generated by the sidescan is run through a software package which generates an image based upon vessel track and dGPS coordinates. Objects in the size range of 10 cm can be determined, and eelgrass also shows up clearly (Figure 3).

SportScan images are ground truthed by the use of a drop camera to verify that textures recorded by the sidescan unit are consistent with the actual objects on the bottom. For example, large steep-sided boulders can look like a patch of eelgrass on the sidescan image. The only way to be certain of the true identity (boulder or eelgrass) is to drop a camera on the object and check.

The drop camera rests on a tripod which is held vertically over the side by a cable run through a davit. The davit has the dGPS antenna mounted directly above the camera tripod, so the dGPS coordinates match the camera position, which is looking vertically downwards. The

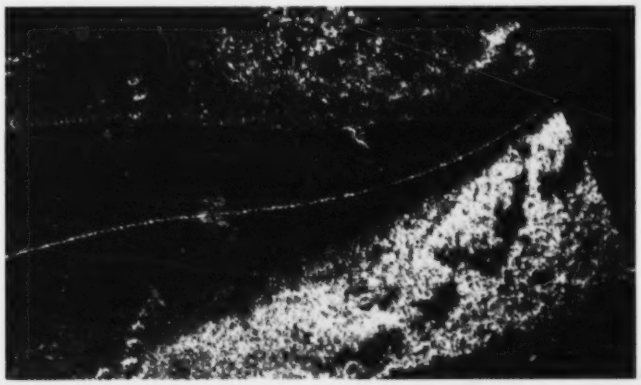

Figure 3 High frequency sidescan image of the bottom shows artificial reef material on the left (spheres) and eelgrass on the right ("clouds" with shadowed edges).

Figure 4 Eelgrass on a sandy bottom

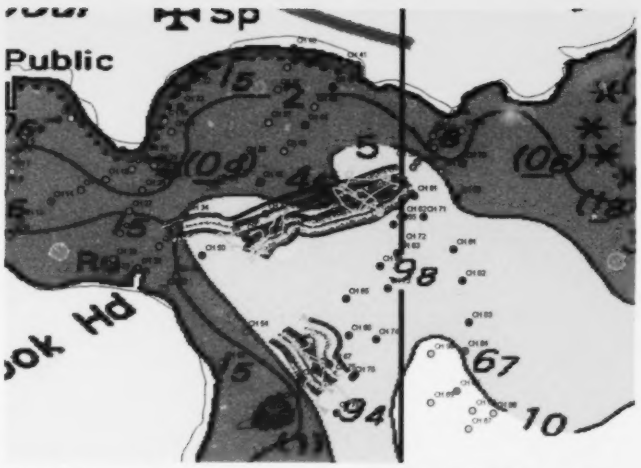

Figure 5 Screen shot of GIS for Cook Head area of Sambro Harbour shows drop camera video clip positions (labelled colour circles), experimental sites (red circles), track of the towed camera (brown lines), starting point of towed video clips (green arrows), and sidescan tracks (greyscale swaths through experimental sites).

data string coming from the dGPS unit is run through a video overlay which places a date, time, and latitude/longitude stamp on each frame of video captured from the camera (Figure 4). Twin lasers mounted 10 cm apart on the tripod provide a consistent scale for the video footage.

We also map the nearshore bottom in colour using a towed camera system consisting of a low-light video camera mounted on a delta wing towfish with a transponder attached. The signal from the transponder (an audible click) is picked up by a transceiver mounted to the hull of the boat; the transceiver data are processed by an onboard notebook computer along with vessel dGPS and digital compass data. The computer calculates the true dGPS coordinates of the towfish in real time as it is pulled behind the boat. The output is recorded to disk and sent to a video overlay for incorporation into each frame of video collected. A laser scale similar to that used with the drop camera is applied. We have used this equipment in Nova Scotia in River Denys Basin, Halifax Harbour, and Sambro, and in New London Bay, Prince Edward Island. To further explore the nearshore bottom, the purchase of an echo sounder-based bottom classification system (e.g., BioSonics® or Quester Tangent™) is planned.

All data (sidescan images, drop camera position coordinates, towed camera tracks, and video clips) are embedded into Arc View GIS projects with digital chart bathymetry as the background (Figure 5). The result is a powerful database which can be examined in different ways to answer our original question, "What does the bottom look like?" This knowledge will contribute to the successful management of this precious resource – the nearshore.

Artificial Reefs: Homes for Benthic Diversity

Glyn Sharp, Bob Semple, Megan Veinot

Figure 1 Placement of Reef Balls at Paddy's Head, St. Margaret's Bay, June 2005

Figure 2 Diver census of animals and plants on Reef Balls

Fisheries and Oceans Canada is faced daily with decisions regarding nearshore benthic habitat alteration, disruption, or destruction through oil and gas, wharf, and other coastal infrastructure projects. One option under the *Oceans Act* is to request the proponents of these projects to compensate for the habitat loss. This raises many questions: what is reasonable compensation; what is the best type of

replacement habitat; and how much artificial habitat is needed to compensate for the habitat loss? Should like habitat be replaced with like; does one unit of artificial habitat equal one unit of natural habitat; is artificial habitat equivalent in productivity, complexity, and diversity to natural habitat?

The concept that humans can design, engineer, and build habitats that are equivalent to, or better than, those provided by nature may be arrogant in the extreme. Natural benthic habitats have a complex architecture of mixed rock, sand, and mud that are further modified by the plant and animal community. Scientists with DFO's Population Ecology Division (PED) at BIO are attempting to answer some of these fundamental habitat compensation questions, first in the context of evaluating an off-the-shelf habitat called Reef Ball™. Reef Balls were initially designed for replacement of coral reefs damaged by storms and human impacts.

To compensate for habitat loss at the entrance to Halifax Harbour, 40 Reef Balls were provided by a company who infilled part of the shallow sub-tidal waters in Eastern Passage. The PED took the responsibility for placing and monitoring colonization of these beehive-shaped concrete units weighing 300-400 kg each. In the summer of 2005, Reef Balls were placed in water 10 m deep on flat gravel bottoms in two locations near Halifax. The site at Paddy's Head, St Margaret's Bay, was pristine, compared to the one at McNabs Island in unclean Halifax Harbour. Once a month, divers take a census of the animal and plant community, photo-documenting marked areas of each Reef Ball. Yearly, 100-cm^2 sections of each Reef Ball are scraped and suctioned to sample the smallest animals and plants.

These concrete structures were rapidly occupied by local inhabitants. After one year, a suite of 55 species occupied the Reef Balls. The first explorers of this new habitat were local crab species: hermit, jonah, rock, and green. They were followed by snails eating the first microscopic stages of seaweeds settling on the structures. Hydroids (sessile invertebrates that resemble small marine plants) provided food for small beautiful nudibranchs (snails without shells). Very small invertebrates, called isopods and amphipods, grazed on the developing seaweed community.

The plant and animal architecture of the Reef Ball was made more complex by rapid development of algal cover, first transitory algae and then perennial kelps forming a canopy up to 1.5 m high (Figure 3). Juvenile stages of fish, blennies, sculpins, snail fish, lumpfish, and white hake were common inhabitants taking advantage of the new food sources (Figure 4). In general, the occupants of the Reef Balls were also residents of the adjacent rocky or gravel bottom. Surprisingly, the community of Reef Balls at the "dirty" McNab's site was as diverse as at the "pristine" Paddy's Head site.

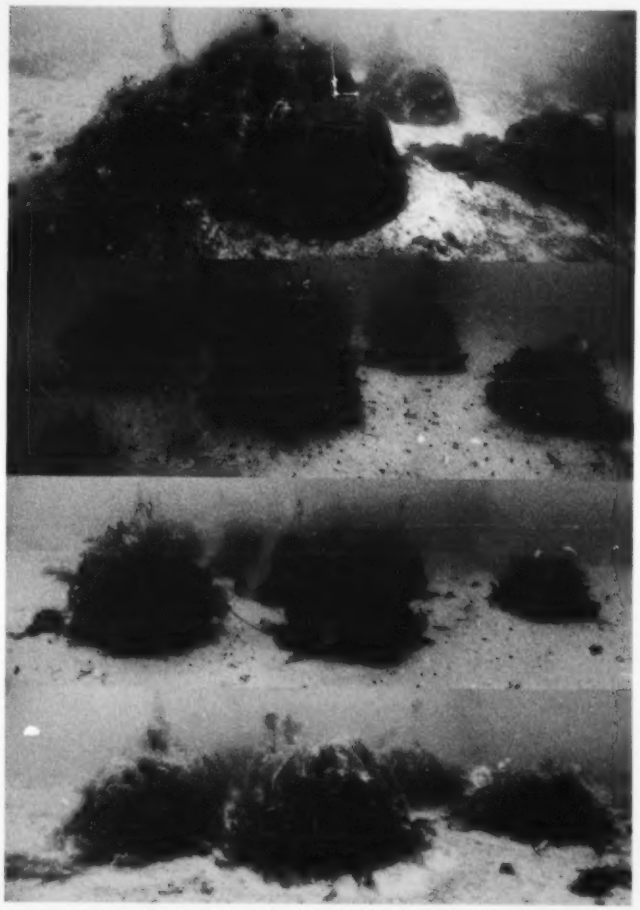

Figure 3 Community development and habitat complexity of Reef Balls, June 2005 - May 2006

The value of Reef Balls as lobster habitat was limited as each unit has only one large space which appeared to be occupied only seasonally, and then periodically by large lobsters (>90 mm carapace length [cl]) (Figure 5). The maximum observed occupancy was 4 of 12 reef

Figure 4 Lumpfish in the seaweed canopy of a Reef Ball at Paddy's Head

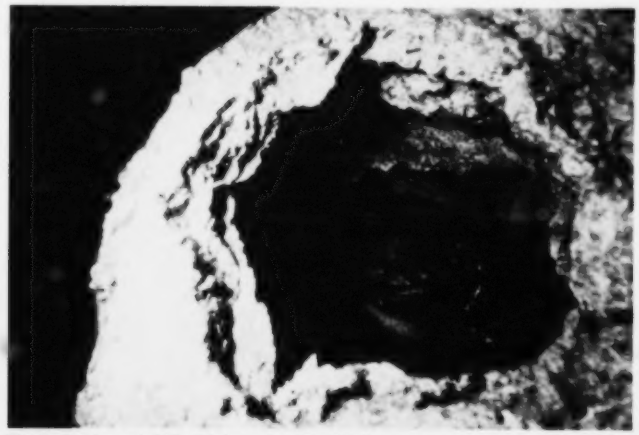

Figure 5 A large (>100 cl) lobster in a Reef Ball

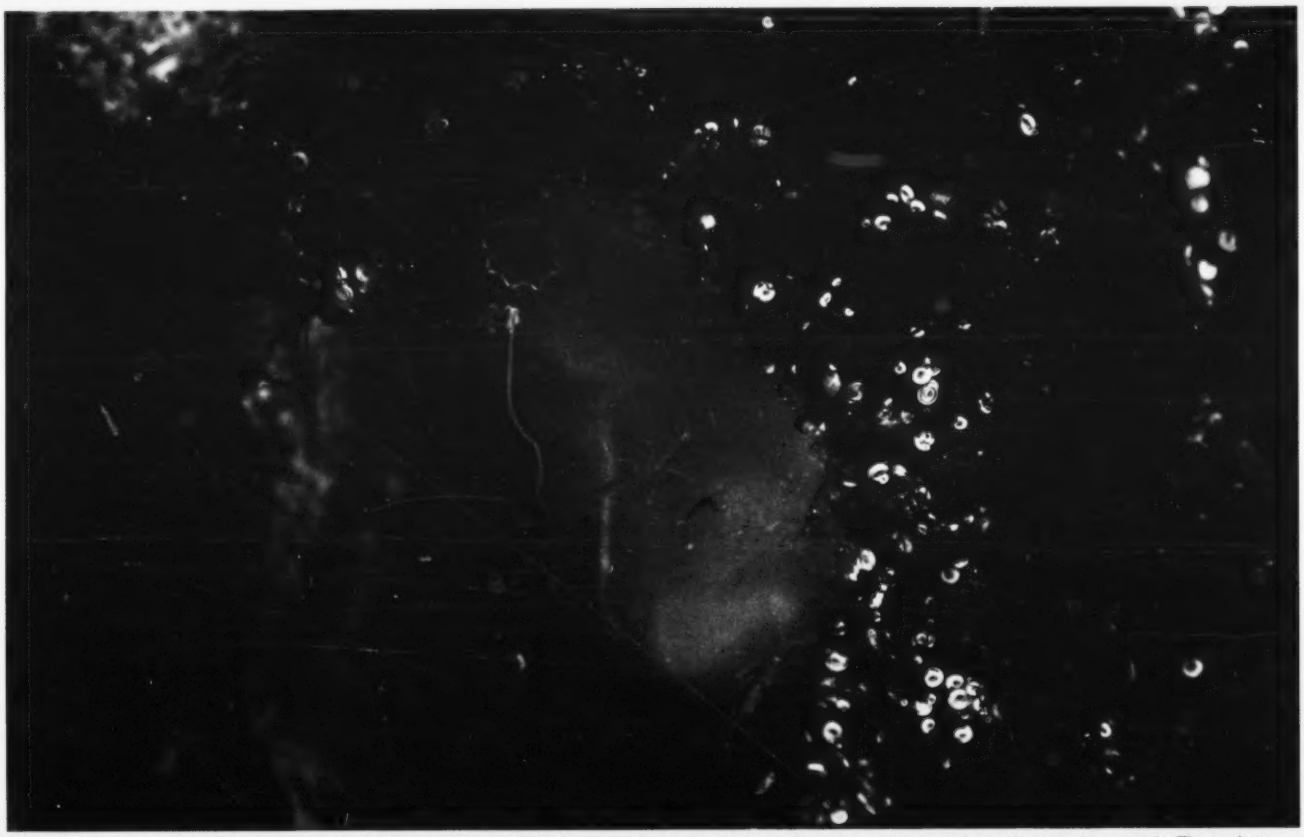

Figure 6 A sea vase tunicate (*Ciona intestinalis*) lives on the reef ball. Many small skeleton shrimp (*Caprella spp.*) are on the tunicate and seaweeds. The tunicate will survive only until the water warms in the summer and will be eaten when the crabs become active.

balls at Paddy's Head and 5 of 24 Reef Balls at McNabs Island. This was not a surprising result as lobsters are very territorial and are unlikely to share the same space in one reef ball. With the support of the Small Crafts Harbours Division of DFO, we are now engaged in a study to determine the best design of an artificial reef for lobsters.

By experimenting with rocks of different sizes and shapes, and rock piles of different diameters, the optimal design of rock reefs was defined. The design was tested in small field experiments at McNabs Island and, in 2006, was used to build six large reef modules that were deployed in Sambro Harbour. The PED is monitoring the occupation of these reefs by lobsters and observing the community as a whole with the aim of providing cost-effective compensation for lobster habitat loss.

Overall, Reef Balls may not be optimal or cost effective as lobster habitat replacement; however, when placed on a sand or gravel bottom, they increased the complexity of the habitat, the primary and secondary productivity, and the overall biodiversity. They are providing a degree of compensation for negative impacts on marine habitat and are valuable in providing reference sites for long-term monitoring of ecosystem health.

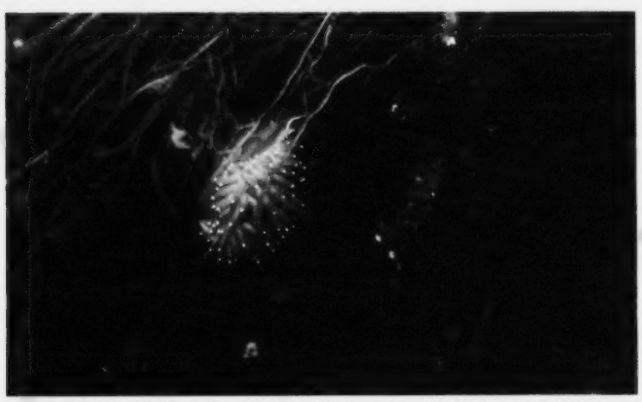

Figure 7 A red-gilled nudibranch (*Coryphella verrucosa*) feeds on tubularian hydroids (*Tubularia spp.*).

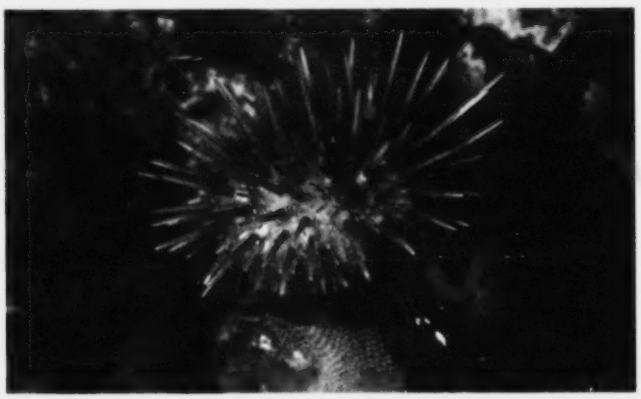

Figure 8 A green sea urchin (*Strongylocentrotus droebachiensis*) feeds on the holdfast of a broadleaf kelp (*Laminaria spp.*) attached to the reef ball.

Why Study Biological Oceanography?

Trevor Platt, Shubha Sathyendranath, and Venetia Stuart

Biological oceanography is the study of all forms of life in the oceans, from microspopic plants to fish and whales, and the processes that govern their distribution, abundance, and production. The ocean covers about three quarters of the surface of planet Earth. Populations of fish and other marine life that can be exploited for food live there, as well as microscopic biota (plant and animal) of paramount importance for the health of the planet. Our principal motivation for the study of biological oceanography is to understand the structure and function of the marine ecosystem, in order to manage the ocean in a way that will not compromise the ecosystem's integrity.

The base of the food chain that supports all life in the sea is phytoplankton. This microscopic plant community consumes carbon dioxide, a greenhouse gas implicated in global warming. Earth's temperature is modulated by the presence of carbon dioxide in the atmosphere. Activities such as the combustion of fossil fuels contribute to the release of carbon dioxide to the atmosphere, leading to the well-known greenhouse effect. Consequently, the scientific community is taking an increased interest in the biogeochemical cycle of carbon and other elements through the atmosphere, ocean, and land. In effect, this is one connected cycle because the three components are in intimate contact with each other.

Phytoplankton are a significant player within the cycle of carbon. They consume about fifty thousand million tonnes of carbon per year via the process of photosynthesis, and also respire carbon dioxide, thus returning a portion of their consumed carbon to the environment. (However, some of the carbon remaining in the phytoplankton cells will sink to a deeper layer of the ocean, where it can no longer participate in the greenhouse effect.) Scientists need to understand the exchange of carbon among the land, oceans, marine sediments, and atmosphere to determine whether these are functioning as a source of sink for carbon dioxide. In particular, biological oceanographers study the carbon flux through marine phytoplankton and how it may be modulated by climate change.

Phytoplankton capture energy from the sun by means of pigment molecules, notably chlorophyll-a (a green pigment). Phytoplankton also contain other pigments with different colours and properties (Figure 1). Some of these, called photoprotective pigments, help prevent excessive damage to the cells from solar radiation.

The presence of pigments in phytoplankton affects the colour of the ocean, changing it from blue to green where phytoplankton are abundant. These differences in colour can be quantified by satellite remote sensing of ocean colour, and the results can be used to estimate the concentration of pigment in the water, which is an index of phytoplankton biomass. The use of data collected in this way has revolutionized biological oceanography during the last twenty years or so.

Study of the pigments in phytoplankton, identified and quantified by High Performance Liquid Chromatography, can reveal the taxonomic structure of phytoplankton assemblages. Some phytoplankton groups are of great significance for biogeochemistry, the carbon cycle, and climate change. For example, the diatom group constructs an outer skeleton of silica, whereas the armoured dinoflagellates make plates from cellulose. The coccolithophore group makes plates of calcite, a form of calcium carbonate, and therefore has a requirement for inorganic carbon beyond that needed for photosynthesis. This is an important factor in the planetary cycle of carbon.

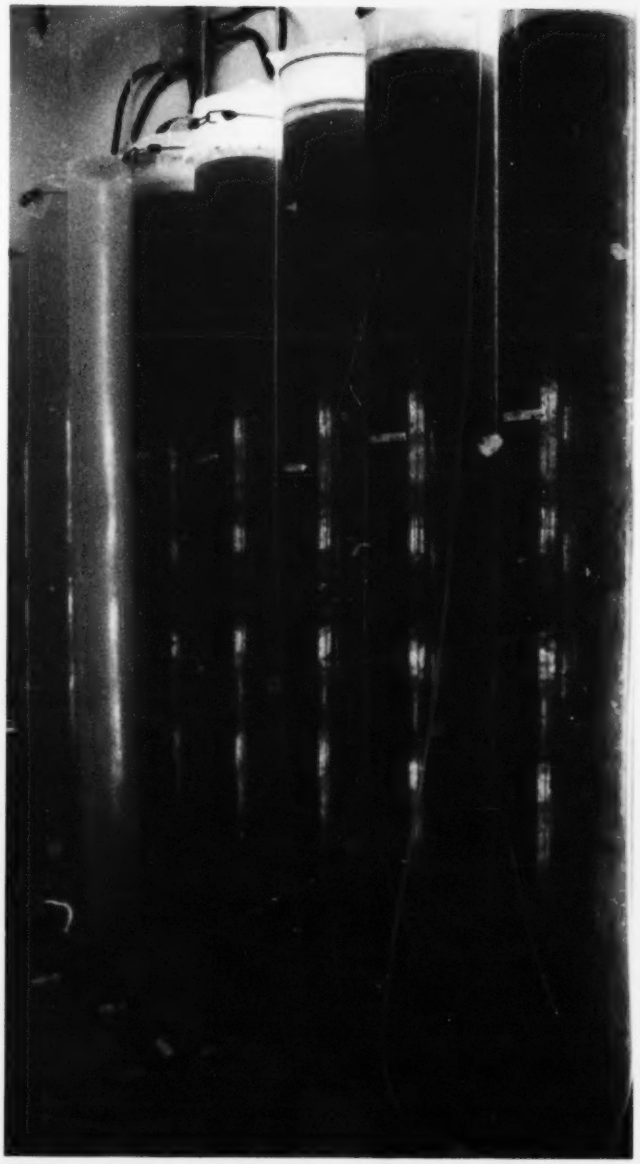

Figure 1 Mass cultures of marine phytoplankton for feeding to invertebrates are grown at BIO. Note the distinctive colouration associated with the different species under culture, a consequence of their different pigment complements.

Oceanographers are interested to know not just the total phytoplankton biomass, but also the distribution among the Phytoplankton Functional Types (PFTs). Coupled ecosystem-circu-

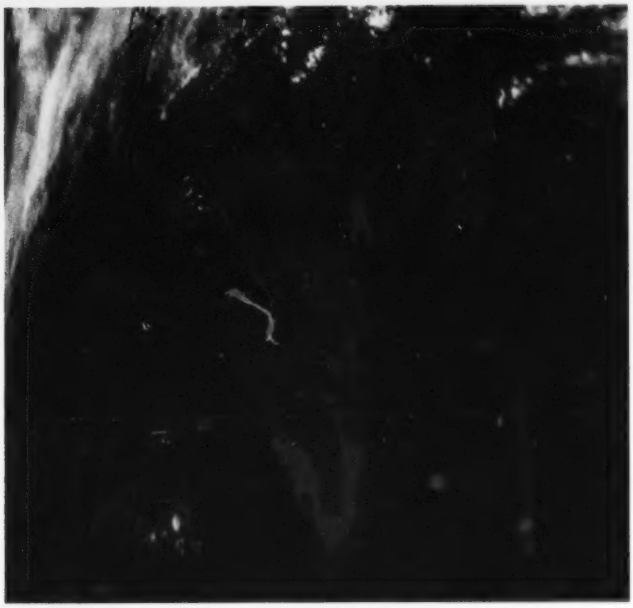

Figure 2 Satellite ocean-colour image shows a phytoplankton bloom off Vancouver Island, most likely composed of coccolithophores. Image was acquired by NASA's MODIS ocean-colour sensor on June 25, 2006 and is courtesy of Jeff Schmaltz, MODIS Land Rapid Response Team at NASA/GSFC.

lation models are now being implemented with the phytoplankton compartment divided into PFTs. One of the frontiers of research is to develop ways to recognise PFTs from remote sensing. Coccolithophores can be recognised because of the intense scattering of light from their calcite plates, which gives the water a milky-blue appearance (Figure 2). Recently, a method was published to recognize diatoms from remotely sensed data on ocean colour (Figure 3).

Oceanographers are also interested in the rate of photosynthesis (primary production) of the phytoplankton, which can be calculated from satellite images of phytoplankton distribution and from measurements of the photosynthetic response of phytoplankton assemblages to light (Figure 4).

In temperate latitudes, a strong seasonal cycle in phytoplankton production – the spring bloom – stimulates growth in other parts of the food chain. In particular, many fish and invertebrates time their spawning to coincide with the spring bloom. Although the occurrence of a spring bloom is a reliable feature in temperate latitudes, the timing of the event may vary from year to year because the responsible factors (wind, cloud cover) also vary. In some years, spawning of fish and invertebrates coincides better with the spring bloom than in others. In years when the match was good, the growth and survival of larval fish and invertebrates has been found to be better than in years of mismatch. By using remotely sensed data on ocean colour, oceanographers can examine the timing, initiation, amplitude, and duration of

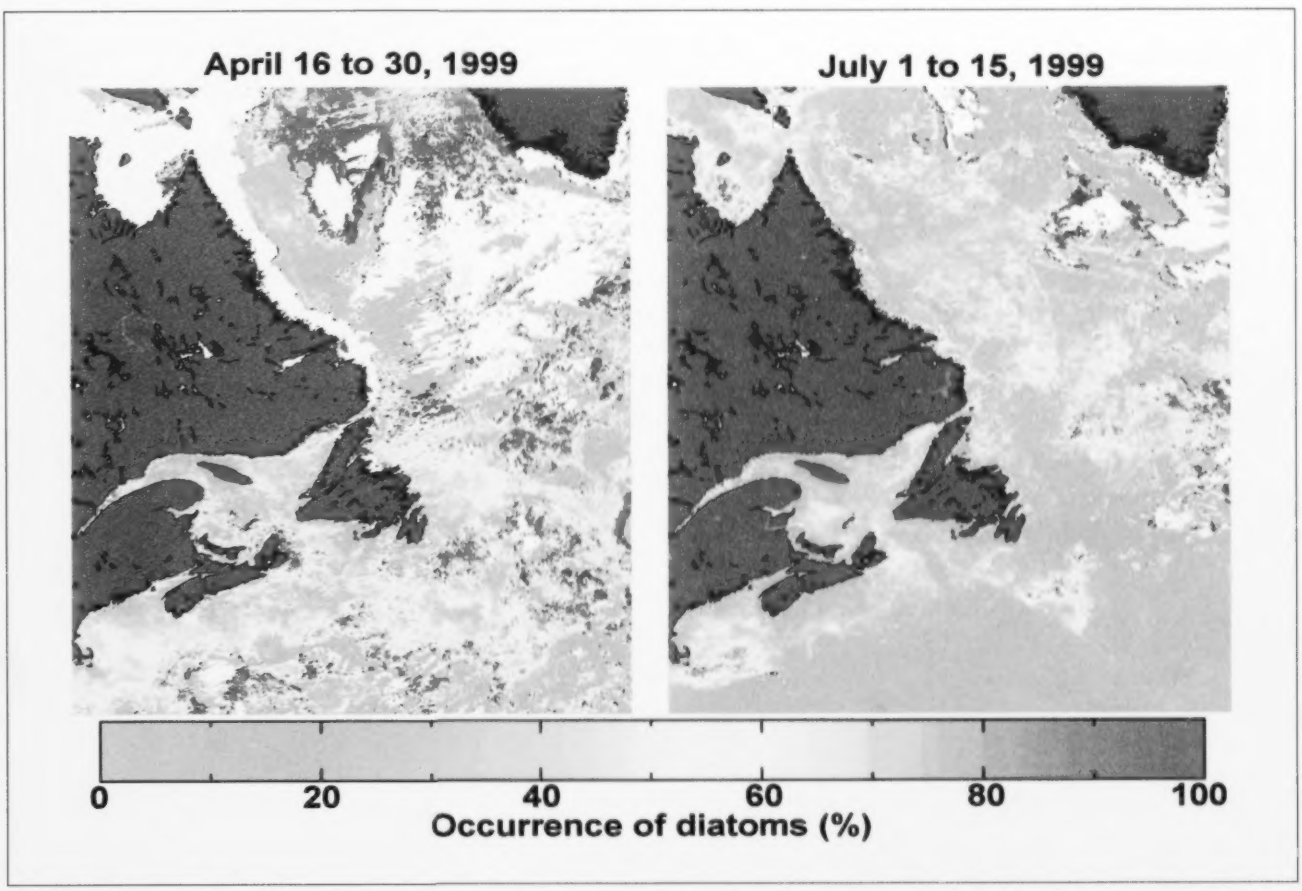

Figure 3 Satellite-derived maps show the distribution of diatoms in the Northwest Atlantic Ocean during two seasons (adapted from Sathyendranath et al., 2004).

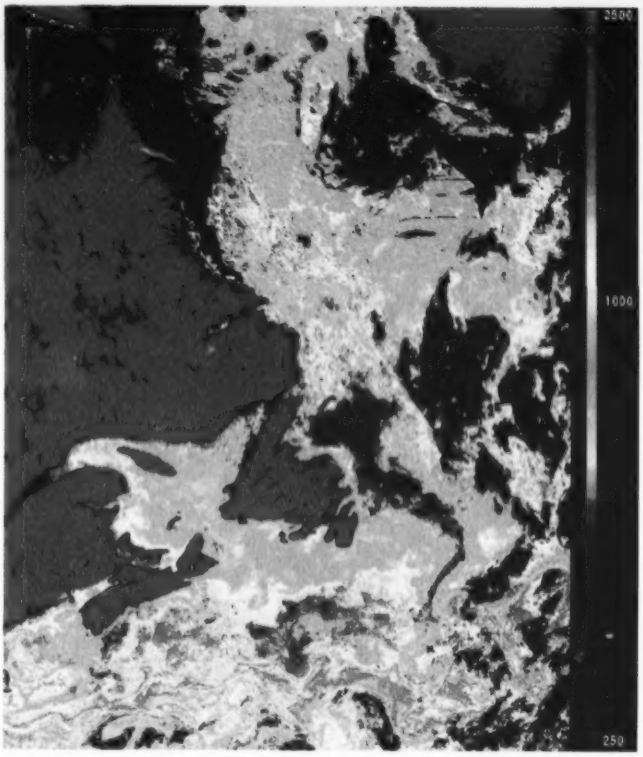

Figure 4 Composite image of primary production of the Northwest Atlantic Ocean, June 1-15, 2004

the bloom in an operational manner, without losing any of the spatial structure in the chlorophyll fields. Through the use of such time series, it has been found, for example, that the timing of the spring bloom in Atlantic Canada may vary by about six weeks. This has potential significance for the rest of the ecosystem including fish. In a thirty-year time series of metamorphosed haddock (*Melanogrammus aeglefinus*) larvae, there were two exceptional year-classes (1981 and 1999), both of which occurred in years when the spring bloom was unusually early (Figure 5). This is strong evidence that disturbances at the base of the marine food chain have important consequences elsewhere in the food chain, including exploited fish stocks, emphasizing that these stocks should be managed on an ecosystem basis.

Marine microbiota play a fundamental role in the great biogeochemical cycles of planet Earth; thus, oceanographers study them as

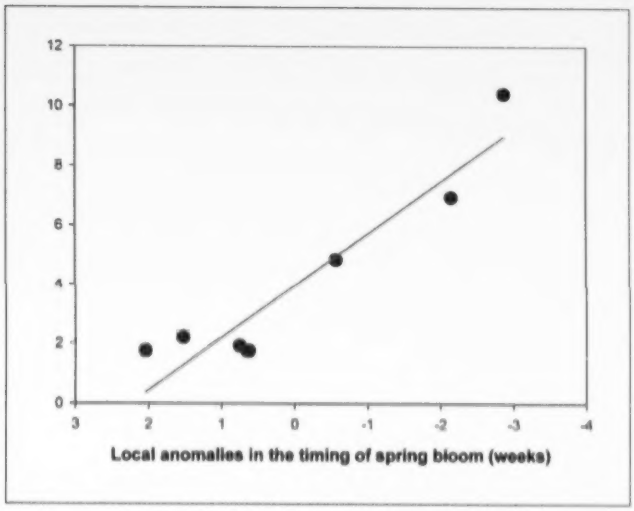

Figure 5 Relationship between survival of larval haddock normalized to spawning-stock biomass, and timing of the spring bloom of phytoplankton on the continental shelf of Nova Scotia (adapted from Platt et al. 2003)

a step towards understanding the causes and effects of climate change. Also, we seek to elucidate their role at the base of the marine food chain, and to bear in mind how fluctuations between years influence the status of exploited species. It is necessary to understand the extent to which phytoplankton regulate the structure and function of the marine food web, in contrast to the regulatory role of the larger predators. From the foregoing, it is apparent that biological oceanography is a fascinating, unfolding field of study that has a great deal to reveal about issues of societal interest.

(This article is condensed from a much longer treatment of the subject by Platt, Sathyendranath, and Stuart, published in Japanese in the journal Aquabiology Vol. 28, No.5, 2006).

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BIO SCIENCE IN PARTNERSHIP

Variation in Moult Timing and Market Quality in the American Lobster *(Homarus americanus)*

Aaron Retzlaff (Fishermen and Scientists Research Society and Atlantic Veterinary College [AVC] Lobster Science Centre, University of Prince Edward Island [UPEI]); Ross Claytor, Brian Petrie, Cheryl Frail, John Tremblay, and Doug Pezzack (DFO); and Jean Lavallée (AVC Lobster Science Centre, UPEI)

The lobster fishery in Lobster Fishing Areas (LFAs) 33 and 34 accounts for 40% of Canadian lobster landings and was estimated in the 2004-2005 season to be 19,500 metric tonnes. Lobsters are a highly valued resource and represent an important source of income to communities of southwestern Nova Scotia. In the 2003 lobster fishing season, economic loss was caused by unusually high numbers of soft-shell and low meat content (low-yield) lobsters in these fisheries. Understanding the cause of these low-yield lobsters is essential for maintaining the viability of these fisheries.

Moult timing in relation to time of harvest is a key factor in the quality of lobsters in the marketplace. A combination of moult stage and blood protein values are indicators of this quality. Lobster blood, like vertebrate blood, carrys oxygen and clotting and immune system proteins. The lowest blood protein values occur directly after moulting when the lobster expands the capacity of its newly formed shell by ingesting copious quantities of water, thus diluting blood protein values. A high blood protein value is found when muscle tissue has replaced water and filled the shell, about two months after moulting. Knowledgeable and discerning consumers prefer these hard-shell lobsters because they usually contain more, and better quality, meat.

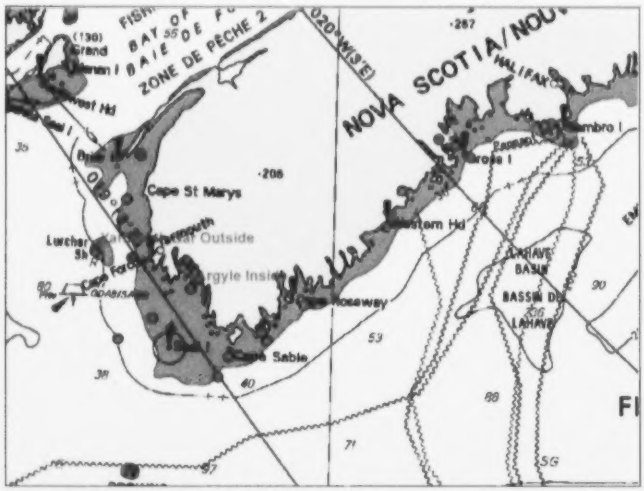

Figure 1 Blood protein sampling sites from LFAs 33 and 34

It is suspected that the increase in low quality lobsters in 2003 was due to a change in the normal moulting period. Water temperature is the factor that most strongly affects moult timing. During the 2003 fishing season, the 2.5° C reduction in mean ocean bottom temperature at the same time as soft-shell/low meat yield is evidence that water temperature is the overriding factor influencing the timing of lobster moulting in LFA 34. As offshore lobsters are thought to moult later than inshore lobsters, this increase in low-yield lobsters may have been compounded by a decrease in effort in traditional inshore areas and an increase in mid-shore and offshore portions of the LFA 34 fishery since the 1998-1999 season, although most effort still occurs in the inshore area. Nutrition, food availability, population density, and social interaction also can affect the moulting cycle but are less important than water temperature.

Because water temperature is the dominant factor affecting moult timing in lobster, a cooperative study was initiated in 2004 to better understand the relationship between lobster quality and water temperature. DFO's Population Ecology Division (PED) at BIO is a participant in this study with partners from the Fishermen and Scientists Research Society, the Province of Nova Scotia, the Atlantic Veterinary College Lobster Science Centre at the University of Prince Edward Island, LFAs 33 and 34 Advisory and Science committees, Nova Scotia Fish Packers Association, Clearwater Seafoods, and the Lobster Action Committee from LFA 34. This report will focus only on results from LFA 34 during Phase 1 of the study.

To determine differences in moult timing, lobsters of different sizes and sexes were sampled from sites ranging from Sambro to St. Mary's Bay (Figure 1). Most of the temperature and environmental changes that affect lobster moult timing occur during the time the

lobster fishery here is closed (June to November). Therefore, it was necessary to carry out sampling outside of the regular fishing season. Blood protein levels were estimated using the Brix Index, which is the standard measure of blood protein levels used in the industry.

The first and most important comparison was between offshore (deep-water) lobsters and inshore (shallow-water) lobsters. It was found that lobsters from the Yarmouth Bar Outside site generally had a lower blood protein level and a later moult than the Argyle Inside site lobsters (Figure 2). Yarmouth Bar Outside temperatures are less variable and slower warming in the spring than those from Argyle Inside; it is likely this slower warming trend is partially responsible for the observed difference in moult timing.

Temperature data came primarily from the FSRS recruitment trap program, supplemented by opportunistic sampling associated with other surveys and the coastal temperature data base. Only data at consistent depths and locations were used. Temperature also was likely relevant in the significant differences in blood protein between years (Figure 3). The 2004 moult occurred approximately 20 days later than in 2005 and 2006. Temperature profiles (calculated using a method similar to a running average smoothing technique [loess method]), indicate an advanced warming trend in the spring temperatures in 2005 and 2006 over 2004. However, it is unknown whether this trend continued as no water temperature profile for the summer of 2006 is yet available.

The study also provided information about moulting behaviour in relation to lobster size. The relatively small reduction in blood protein levels during the fall moult indicates that fewer of the small lobsters (less than 82.5 mm carapace length [cl]) are moulting at the same time, and the smaller lobsters are moulting later than the two larger classes studied (Figure 4). These differences are more likely related to life history than temperature differences, because each group was subjected to the same environmental temperatures. That larger lobsters moult first does not match fishermen's expectations and experience and is surprising to them. Additional analysis of the data will be required to explain this result. The fishermen on our committee suggested that analysis by area and moult stage might help with the interpretation of these results. This idea will be examined in the next step of the analysis.

The two larger carapace classes exhibited a similar moulting pattern. Both groups of lobsters that were >82.5 mm included immature and mature lobsters because, for this geographic area, 50% of

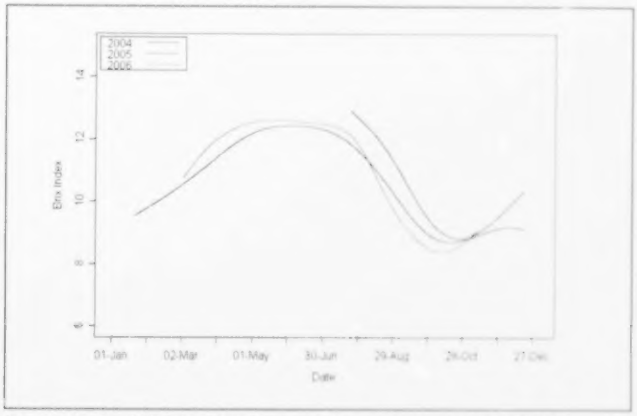

Figure 3 Annual blood protein-level variation, between 2004 and 2006

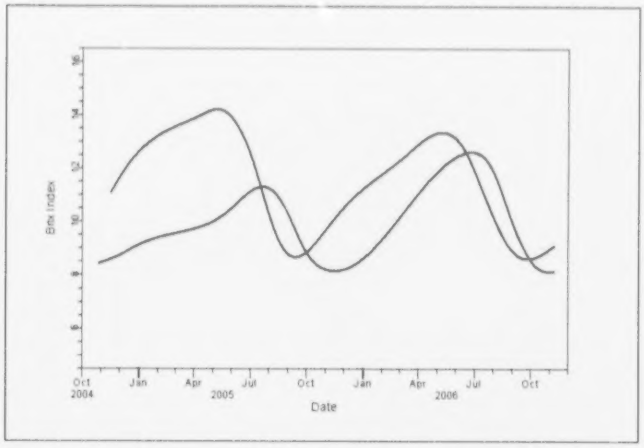

Figure 2 Chart shows the variation in blood protein levels between a deep area (Yarmouth Bar Outside) (red line) and shallow area (Argyle Inside) (blue line) of LFA 34, 2004-2006.

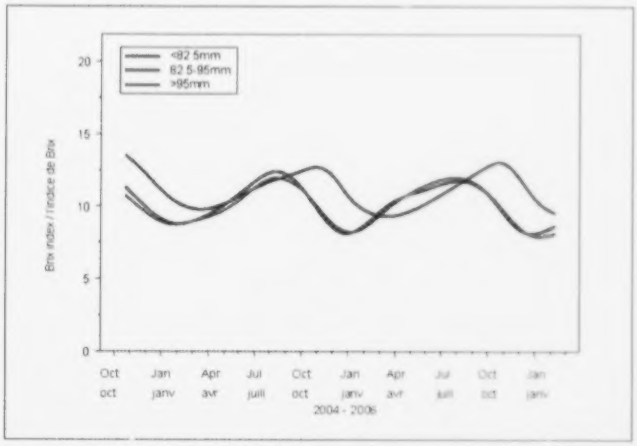

Figure 4 Blood protein levels for three carapace length classes, 2004-2006

Figure 5 Sampling lobster blood protein occurs at sea using lobster fishing boats: from left are: Cheryl Frail, sampling blood protein; Ross Claytor, measuring; and Ron Duggan, tagging lobsters.

Figure 6 Blood is sampled from the lobster body cavity using sterilized syringes.

lobsters are mature at 95 mm cl. The similarity in moulting patterns within these groups indicates that moult timing is not related to sexual maturity; otherwise, a difference within the two larger size groups would be observed. A number of hypotheses related to life-history characteristics need to be investigated to explain these results.

The study also investigated blood protein according to the sex of the lobster. Although differences between males and females were less distinct than those associated with depth, they are statistically significant. To interpret these biological differences will require further exploration.

CONCLUSIONS

Lobsters in deeper waters have a delayed moult cycle relative to shallow-water lobsters with water temperature having a significant influence on this relationship. Between-year differences in blood protein levels are significant: it appears that water warmed more quickly in the springs of 2005 and 2006 than in 2004, resulting in a relatively early moult in those years. Carapace length classes differ in their moult timing as well. Small (<82.5mm cl) lobsters moult later and are less inclined to moult in unison than large lobsters. No obvious influence of maturity state on blood protein levels was observed in lobster larger than 82.5 mm. The sexes differ in their moulting pattern throughout the year, but that is far less pronounced than differences observed between deep and shallow areas. Although other factors regulate moult timing in lobsters, water temperature appears to be the most important.

Monitoring needs to continue in order to understand if the changes are part of a developing trend or a unique occurrence. The continued lobster monitoring will be accompanied by analyzing trends in moult stage, in combination with blood protein, and improved temperature monitoring to better understand and predict low quality years. Future work, depending on funding, would include laboratory experiments to test ideas identified during the field monitoring.

Data from this project is kept up to date on the AVC Lobster Science Centre web site: (http://www.lobsterscience.ca/molt/).

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Tracking North Atlantic Climate

Brenda Topliss (Ocean Sciences, BIO) and Bablu Sinha (National Oceanographic Centre, Southampton, UK)

Regional climate research is just one among many topics studied by DFO's Ocean Sciences Division (OSD) at BIO. However, as neither climate effects nor impacts are confined to national boundaries, we can gain a better understanding of climate through collaboration. In this case, OSD scientists are working with scientists at the National Oceanography Centre in the United Kingdom (UK).

By observing the activity of the oceans, we can learn about climate. Understanding oceanic changes can be difficult since the oceans are not static, but have physical properties that vary widely in both space and time, from centimetres to hundreds of kilometres, from minutes to centuries. However, with climate change studies predicting an increase in climate extremes there is a need to understand anomalous, or "different from average", conditions: for example, has warmer or colder water moved into or out of a given region?

It has long been known that the Gulf Stream moves warm water across the Atlantic, resulting in a warmer winter climate for northern Europe than for the same latitude in Canada. More recently, it has been shown that anomalies (large bodies of water with anomalous properties) can take several years, even decades, to travel across the Atlantic, and that these oceanic anomalies may, as they approach the shelf seas and coastal regions, impact the regional climate through air temperature and precipitation. At other times these propagating anomalies stall and eventually dissipate on one side of the Atlantic Ocean, with variable and less obvious impacts on climate.

To study multi-year or multi-decadal ocean processes, long observational, multi-variable, multi-depth datasets are required, but are rarely available. Global sea surface temperature (SST) data have been interpolated from historic records and are available from 1870 to the present via the Hadley Ice and SST (HADISST) dataset. Filtering the data, to concentrate on multi-year processes, yields propagating SST anomalies lasting between 6 and 13 years as shown in Figure 1.

As a starting point to examining anomalies capable of moving in any direction, a specified track (Figure 1) across the Atlantic was studied using the HADISST dataset. If the bands of colour in Figure 2 are completely horizontal then the warmer or colder water occurred simultaneously across the entire Atlantic in that year; if the bands of colour are sloped upwards from left to right, then a surface feature was propagating eastward across the Atlantic. A strong propagating signal can be seen to start at the left around 1945 and take more than a decade to reach the other side of the Atlantic.

The behaviour of these propagations changed between the period 1948-1970 and the period of 1970-2002. In the former period, SST anomalies propagated from the east coast of North America to the British Isles in approximately 10 years. The anomalies displayed a well-defined life cycle, growing in the western basin (west of 40° W) and decaying in the eastern basin. Analysis of atmospheric datasets shows that these oceanic anomalies have comparable sloped bands in the time-latitude plots of surface heat fluxes and in surface air temperature. Winter surface air temperatures were changed by up to +0.5° C over decadal timescales when an SST anomaly travelling across the North Atlantic reached northern Europe. This represents approximately one-third of the total temperature variation recorded over the UK. However, during the period 1970-2002, SST anomalies did not propagate deep into the eastern basin, but grew in the western basin and then ceased propagating, having no significant influence on European climate.

The processes that drive these anomalies across the Atlantic—advection, winds, and/or surface heat fluxes—may change in different cases and particularly for different time scales. To further study these inter-decadal processes, and particularly to include ocean processes, additional information is sought from computer models, in this case from HADCM3, an atmosphere-ocean, general circulation model developed in the UK. This model has a 1.25° by 1.25° ocean grid with 20 depth levels covering the full ocean depth. Even though powerful computers are used to run such climate models, short climate runs still take a long time to complete. As such, the HADCM3 model is one of the few models to have been run for 1,000 years and to store the full output of oceanic depth variables. Since diverse physical processes can occur at different time scales, the first task is to determine what periodicities (the length of time

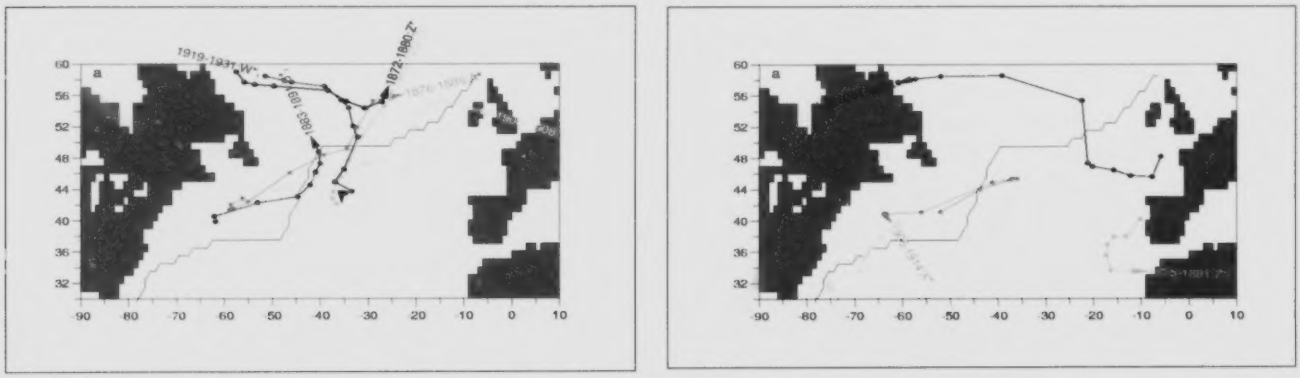


Figure 1a Anomalies that travelled from west to east as far as to mid-ocean or all the way across; **(b)** anomalies that all went in different directions and impacted different regions. The continuous grey line in both figures is the specified track plotted in Figure 2.

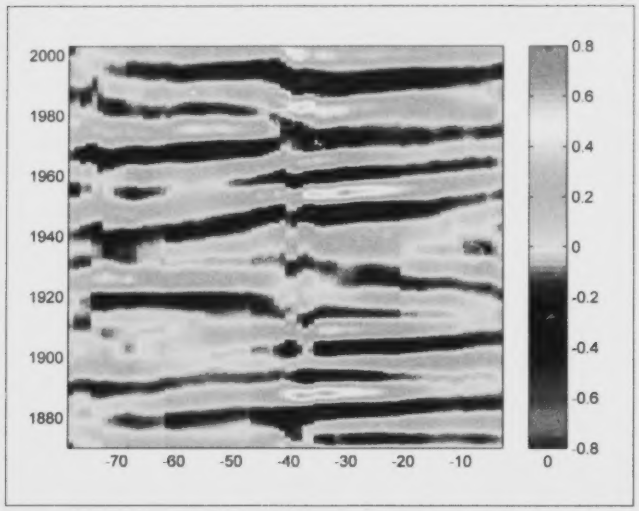


Figure 2 A time-latitude plot of SST annual anomalies (for the grey track shown in Figure 1), colour scale -1° C to +1° C

after which the process repeats itself, e.g., 50 years) are present in a model location and in a variable, and particularly, the changing relationships between variables. Such a first look can be achieved through wavelet analyses. Figure 3 shows this analysis for the thousand years of model data (not "real" years, but for convenience labelled 1850 to 2849) for annual SST and evaporation data averaged along the Labrador shelf.

Figure 3 shows what periodicities are strongly (red) and weakly (blue) correlated for these two variables, and how those inter-relationships change over the 1000 years. There is only an occasional relationship at the inter-annual time scale (< 4 years), a marked on-off relationship at the decadal time scale, and a more consistent strong relationship for longer periodicities (> 25 years), although even for the longer periodicities (~35 and ~120 years) there can be century-long times when the inter-relationship breaks down.

It is hoped that how these changing relationships tie in with the other model climate variables and vary with ocean depth will provide insight into physical processes that may be impacting changes in the real climate environment. Conversely, as we understand more about ocean-atmosphere climate mechanisms these can be incorporated into models, thereby providing greater predictability. In collaboration with the UK Rapid Climate Change program, both ocean depth and meridional overturning circulation (a North American section of the global ocean thermohaline circulation also commonly known as the conveyor belt) are now being added to this study. The intention is that future work will examine long runs from circulation models into which bio-chemical cycles are currently being incorporated. The findings should enhance our knowledge about changes in the associated regional climates.

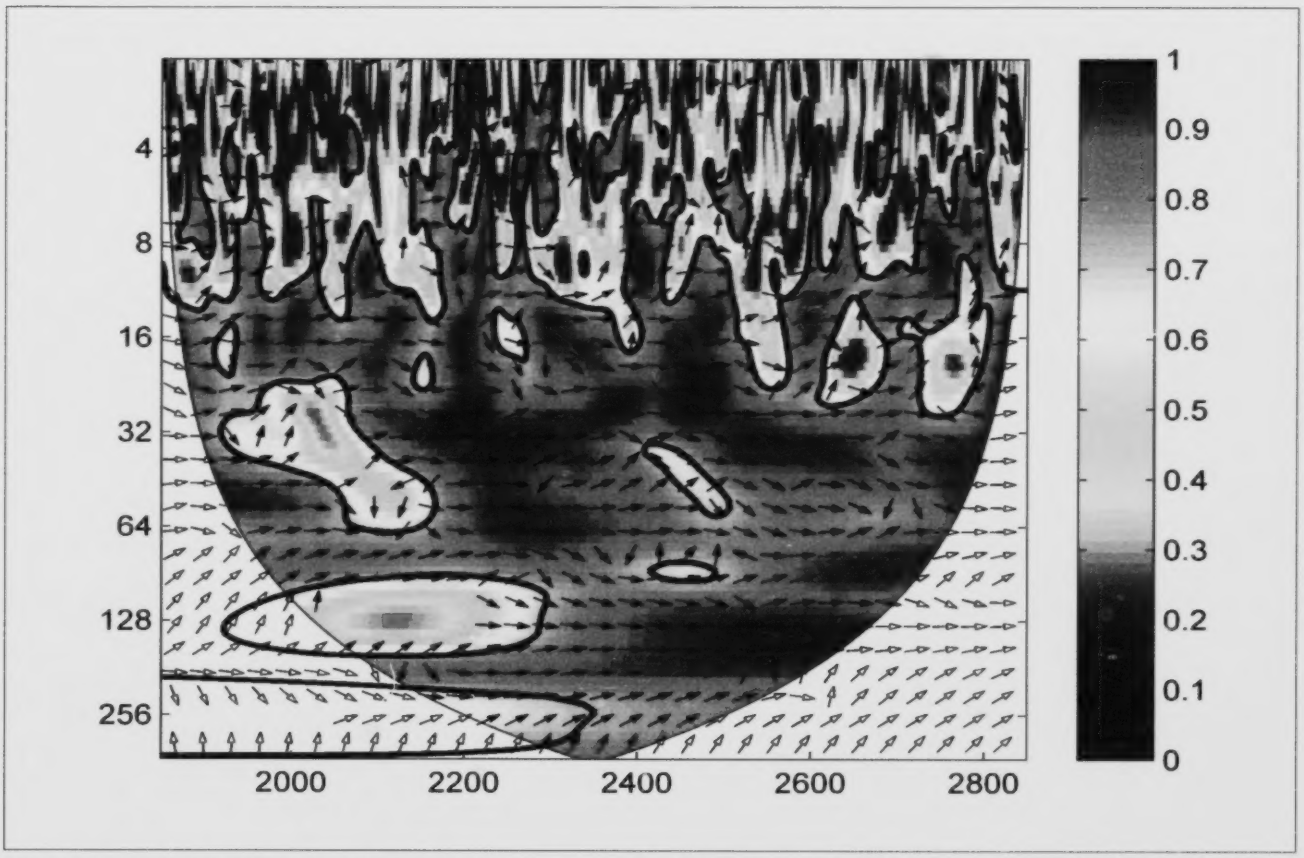


Figure 3 The colour scale (0 to 1) represents the correlation between the variables at different periods (2 to 256 years), over the thousand years. White regions represent periods with insufficient data to be statistically significant. Arrows represent the phase of the relationship: horizontal arrows left to right for variables directly correlated (in phase); right to left arrows for variables inversely correlated (out of phase).

Using Global Earthquakes to Study Atlantic Canadian Geology

Sonya Dehler (GSC Atlantic), John Cassidy (GSC Pacific), and Patrick Potter (GSC Atlantic)

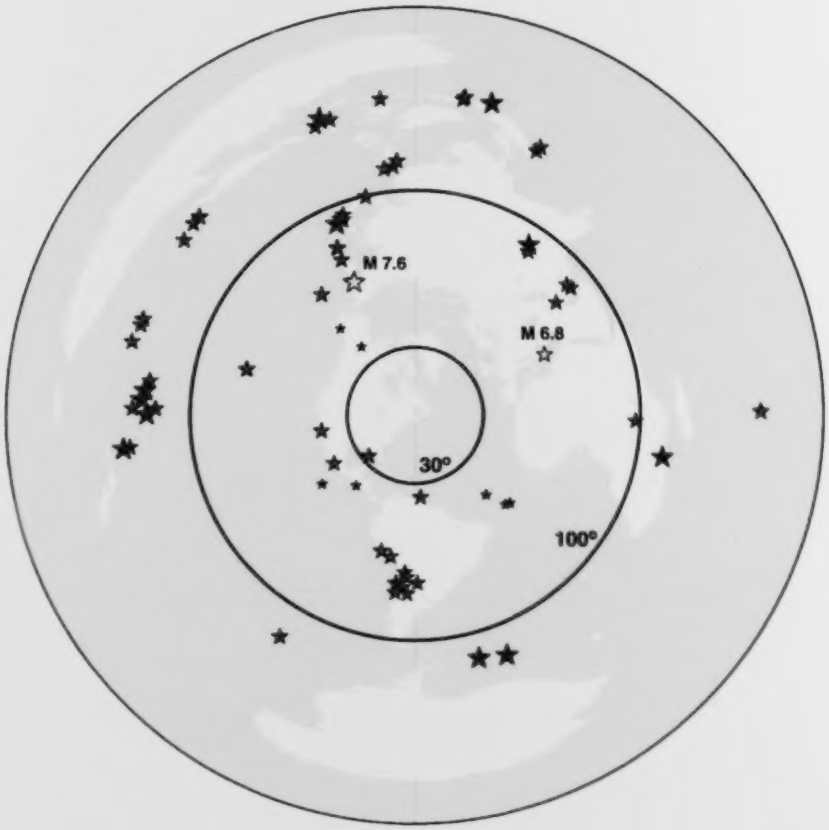


Figure 1 Map shows large earthquakes that occurred during the 12-month period ending October 20, 2006. Large blue stars are magnitude M>7.0; medium red stars are M=6.0 to 6.9; and small black stars are M=5.5 to 5.9. Yellow stars indicate events discussed in the text and Figure 6. Solid circles outline distance ranges suitable for receiver function analysis used in this study.

Each month, more than a dozen earthquakes of magnitude (M) 6.0 (on the Richter scale), or larger, occur somewhere in the world and send energy into the depths of the earth. A network of portable seismic stations, deployed across Atlantic Canada, is recording signals from these distant earthquakes (Figure 1) that impart information on the geologic structure beneath the region. The earthquake signals (teleseismic data) contain information about their paths and the structures through which they travelled. This simple concept underlies the new study by NRCan's Geological Survey of Canada (GSC) to map major geologic boundaries beneath Atlantic Canada.

The method relies on differences in the travel times of different types of seismic waves (vibrations). When large earthquakes occur, they release energy in the form of intense seismic waves which propagate long distances in all directions away from the earthquake (Figure 2). The speed at which the waves travel depends on the physical properties of the rocks through which they pass. Several types of seismic waves are generated: P-waves, which travel fastest; S-waves, which travel more slowly than the P-waves; and surface waves, which travel near the surface of the Earth and, for distant events, arrive much later than the P- and S-waves. Because S-waves travel more slowly than P-waves, the time interval between the P and S arrivals will increase with the distance travelled, and hence can be used to determine distances between the earthquake and the receivers.

Additional S-waves are created when P-waves cross significant boundaries within the Earth. These are called Ps-waves. In the case of distant earthquakes, the P-waves travel at near-vertical incidence beneath the recording site (Figure 3) and dominate the vertical component seismogram. Ps-waves generated by crossing boundaries in our region travel with different particle motion and are best detected on the horizontal seismograms. This is the basis for receiver function analysis (comparing the vertical and horizontal compo-

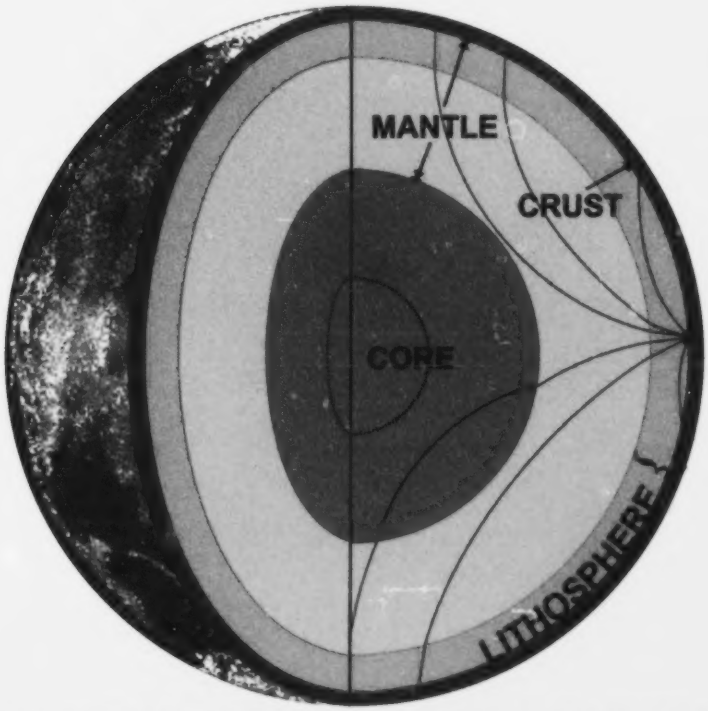


Figure 2 Cross section of Earth shows the major layers and some travel paths for seismic waves from an earthquake occurring near the base of the crust.

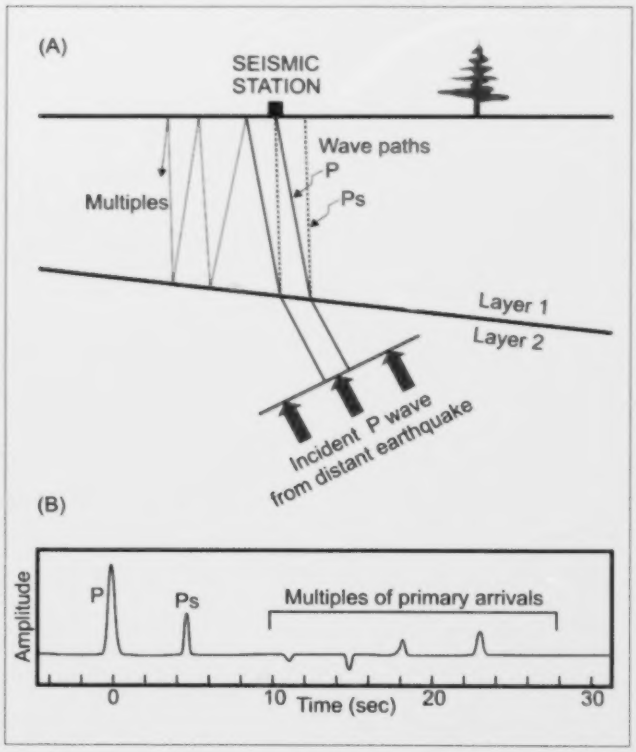


Figure 3 (A) Ray diagram illustrates the Ps conversion that is generated when a P-wave encounters a boundary. (B) The receiver function: the time difference between the direct P-wave (at T=0) and the Ps conversion provides information on S-wave velocity and depth to, and dip of, the boundary.

nents) that allows for these locally generated Ps-waves to be readily identified. The time difference between the Ps- and P-waves provides information on the depth and average velocity to the boundary that generated the Ps phase, and the amplitude of the Ps phase provides constraints on the velocity contrast of that boundary. When possible, receiver functions for several events from a similar direction and distance range are combined through stacking to make it easier to distinguish primary arrivals from background recording noise levels and multiples.

The temporary Atlantic array consists of ten stations that were installed during field operations in fall 2005. Each station uses a digital, three-component, broad-band seismometer, an instrument that measures and amplifies ground motion. The stations also include a satellite communications system and a power source, typically a battery bank charged by solar panels (Figure 4). Data are recorded continuously and transmitted via satellite to data centres in Ontario maintained by the POLARIS[1] Consortium, which also provided the equipment used in this study. Five other stations in the region, part of the permanent Canadian National Seismograph Network (CNSN) of Natural Resources Canada, complete the coverage of Atlantic Canada.

Each station of the Atlantic array is positioned to address a particular geologic problem. The stations loosely form two transects across the region (Figure 5). One of the objectives of this study is an improved understanding of the development of the sedimentary basins underlying the Gulf of St. Lawrence, which are being studied as part of the GSC's Secure Canadian Energy Supply Program. The Gulf of St. Lawrence region experienced a complex geologic evolution that involved two cycles of ocean closure and opening, and included the formation of the Appalachian mountains and modern continental margin. Previous studies of the deep crust in the region have been limited to a few marine wide-angle reflection/refraction seismic lines in the Gulf, and two multichannel seismic lines across Newfoundland (Figure 5). Many questions remain about the nature and position of the geologic fragments that comprise the Appalachians, the thinning of the crust and lithosphere associated with basin formation, the velocity structure and physical properties of the crustal rocks, and sediment thickness. An improved understanding of Appalachian crustal structure will result in better estimates of heat flow from the mantle through the crust and sedimentary rocks at the time the basins formed, and ultimately will help to differentiate between models of basin evolution. In addition, these new stations will aid in the positioning and analysis of local and regional seismic events.

Although data analysis is still in the early stages, several trends are already apparent in the data. For example, there is significant variation among stations in the arrival time of the phase from the base of the continental crust (Moho) along the north-south transect, indicating crustal thickness variations (Figure 6). Stations located in the central part of the region have the earliest Moho arrivals, indicating thinner crust beneath these stations. Earlier arrivals at several other

[1]POLARIS: Portable Observatories for Lithospheric Analysis and Research Investigating Seismicity

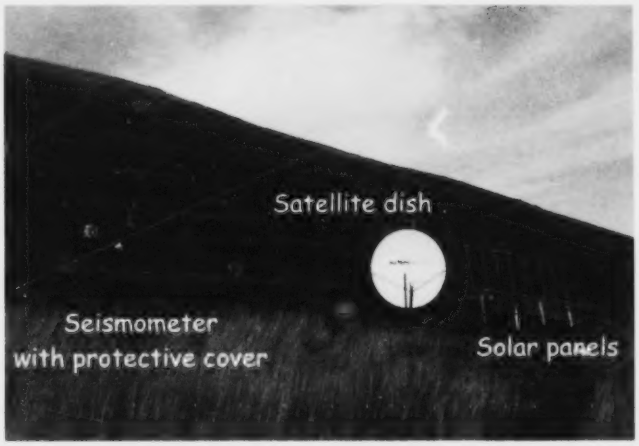


Figure 4 Station MADG on the Magdalen Islands, showing the solar panels, satellite dish, and protective cover over the seismometer

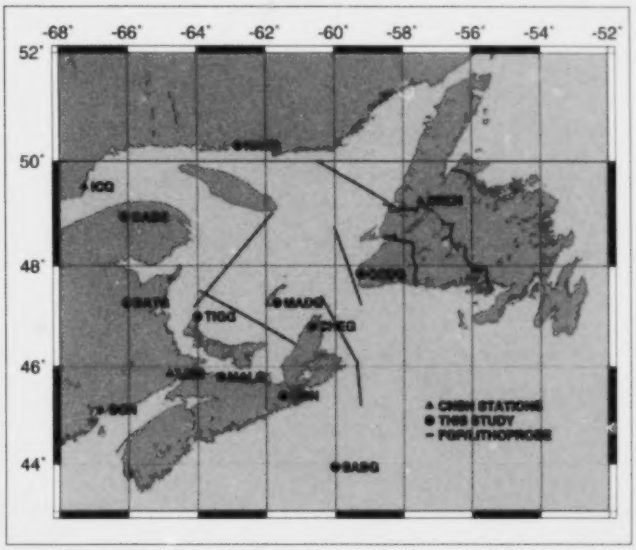


Figure 5 Map shows locations of the Atlantic array seismic stations (this study) and other stations of the CNSN network. Also shown are locations of several deep seismic lines collected between 1985 and 1990 by the GSC's Frontier Geoscience Program (FGP) and LITHOPROBE (a collaborative national research program in the Earth sciences).

stations may be from the top of the crust, which lies buried at several kilometres beneath sedimentary rocks (e.g., 32 seconds, station TIGG, Figure 6). The observations are consistent with what is known about the regional geology and the centrally located Maritimes Basin, a sedimentary basin of Carboniferous age which extends across much of the southern Gulf of St. Lawrence and adjacent onshore areas. Comparing the receiver functions for several stations across the region highlights these differences. The initial observations, and other regional geophysical data such as seismic reflection/refraction and gravity, will be used to constrain numerical models that will establish crustal and basin architecture. When complete in 2008, this three-year study will provide a comprehensive regional comparison of the geologic structure beneath Atlantic Canada.

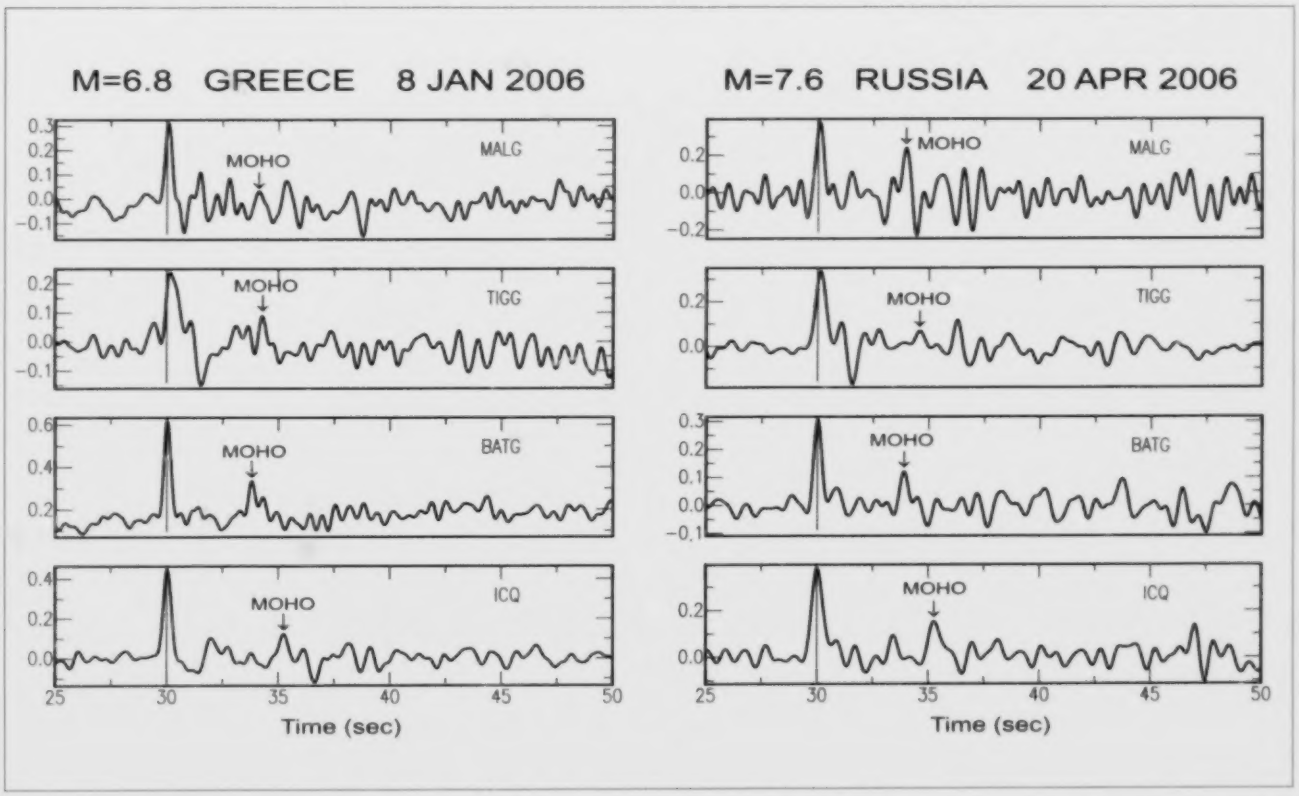


Figure 6 Comparison of radial receiver functions for several stations for recent earthquakes in Greece and Russia: locations of events are shown as yellow stars in Figure 1. The original P-wave arrival is at 30 seconds, and the Ps phase conversion from the Moho is indicated.

Environmental Impacts of Historical Gold Mining Activities in Nova Scotia

Michael B. Parsons

Figure 1 Archival photo shows the recovery of mercury amalgam from copper-plated amalgam tables in the 20-stamp mill, Dufferin Gold Mine, Salmon River, Nova Scotia, 1893. The suspended shaking tables below the amalgam plates were used to recover arsenopyrite concentrates. Tailings from each table were discharged from the mill via a wooden trough. Photo was taken by E.R. Faribault, Geological Survey of Canada and is reproduced with permission of the Minister of Public Works and Government Services Canada, 2007 and courtesy of Natural Resources Canada, Geological Survey of Canada.

Historical mine sites are present in all provinces and territories across Canada. Many of these mines were in operation before the enactment of modern environmental regulations, and may pose significant risks to the environment and human health, through hazards including acid mine drainage, metal contamination, open shafts, and land subsidence. Approximately 10,000 orphaned and abandoned mine sites have been identified in Canada (www.abandoned-mines.org) and most do not have long-term closure plans. The Nova Scotia Abandoned Mine Openings Database contains more than 6500 individual mine openings on private and public lands, including more than 4400 related to historical gold exploration and mining. Since 1984, the province of Nova Scotia has made significant progress in evaluating and reducing physical hazards associated with mine openings on Crown land; however, the environmental and human health hazards associated with historic mine wastes are not well understood.

Nova Scotia has a rich gold mining history. The first confirmed discovery of gold in bedrock in Nova Scotia occurred in 1858 when Captain C. L'Estrange noticed the yellow metal in quartz outcrops while hunting in Mooseland on the Tangier River. Two years later, follow-up prospecting revealed gold showings near Mooseland and Tangier, leading to Canada's first gold rush in 1861. From 1861 to the mid-1940s, gold was mined in 64 districts throughout the Meguma Terrane in southern mainland Nova Scotia, resulting in a total production of 1.2 million ounces of gold (www.gov.ns.ca/natr/meb/pdf/is13.htm). Most of this gold was recovered using stamp milling and mercury amalgamation, whereby the gold ore was crushed to sand- or silt-sized material, and then washed over mercury-coated copper plates. During this process, some of the free gold would combine with the mercury to form an amalgam, which was periodically scraped off the plates and heated in a retort (distilling vessel)

to recover the gold (Figure 1). The remaining crushed material, referred to as tailings, was considered a waste product and was slurried directly into local rivers, swamps, lakes, and the ocean. At most stamp mills, 10–25% of the mercury used for amalgamation was routinely lost to the tailings and to the atmosphere. In addition to mercury added during the milling process, potentially toxic elements (primarily arsenic) occur naturally in the ore and may be present at high concentrations in the mine wastes. Historical production records show that more than three million tonnes of mill tailings were generated at the various gold districts between the 1860s and 1940s.

In the mid-1970s, the potential health hazards associated with these historical mine wastes were first recognized when a resident of Waverley was diagnosed with chronic arsenic poisoning. Studies revealed that the patient's well had been lined with arsenic-rich mine wastes, and the tap water contained 5000 micrograms per litre (µg/L) arsenic, which is 500 times the present-day drinking water guideline of 10 µg/L. Over the last 30 years, there have been a handful of studies on arsenic and/or mercury contamination associated with gold mine wastes throughout the province, but the risks to humans and the environment remain obscure. During this time, ongoing residential development, industrial construction, and recreational activities (e.g., ATV, dirtbike, and 4X4 racing) have increased the potential for human exposure to contaminated mine wastes.

In April 2003, the Earth Sciences Sector (ESS) of Natural Resources Canada initiated a multi-disciplinary project to document the concentrations, dispersion, and fate of arsenic, mercury, and other metals in the environment surrounding abandoned gold mines in Nova Scotia. The main goal of this work is to provide data that can be used to assess environmental and human health risks and support better informed land-management decisions. Our project partners include the Nova Scotia Department of Natural Resources, Environment Canada (EC), Fisheries and Oceans Canada (DFO), and four universities (Queen's, Ottawa, Dalhousie, and the Royal Military College). The ESS receives funding through its programs: Metals in the Environment (2003–2006), Environment and Health (2006–present), and Geoscience for Oceans Management (2003–present). Secondary funding has come from the Metals in the Human Environment Research Network (www.mithe-rn.org/).

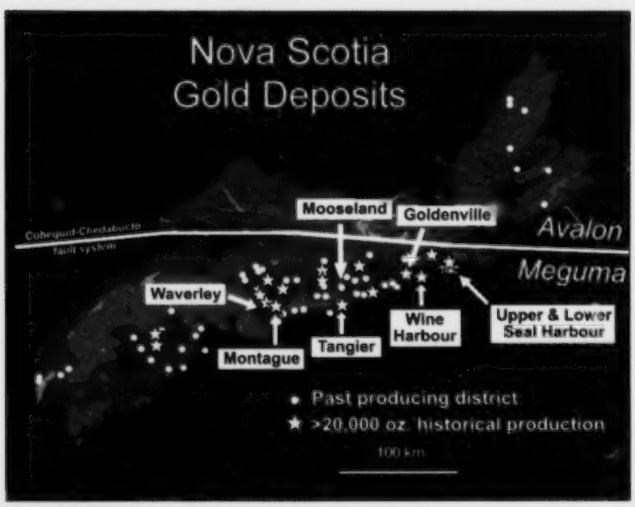


Figure 2 Geological map of Nova Scotia shows locations mentioned in text, including the Meguma Terrane. Base map is from Paul Smith, Nova Scotia Department of Natural Resources.

Figure 3 Off-road vehicles race on historical mine tailings at the 11th Annual Goldenville 4X4 Rally, September 5, 2004, in Goldenville, Nova Scotia. This event was not held in 2006 because of potential human health risks associated with high arsenic levels in the tailings.

From 2003 to 2006, samples of tailings, soil, till, rock, sediment, water, and/or vegetation were collected at 15 past producing gold mines. Marine studies were carried out in collaboration with DFO and EC in Isaacs, Seal, and Wine harbours along the eastern shore to assess the impact of historical marine tailings disposal. Field studies reveal that most mine sites contain large volumes of unconfined tailings, which are generally located in low lying areas downslope of stamp mill sites. In some districts (e.g., Goldenville, Upper and Lower Seal Harbour) the tailings have been transported significant distances (>2 km) by local streams and rivers. At most mines, the tailings are overgrown with vegetation and often difficult to recognize; however, some tailings deposits have recently been disturbed by human activities (e.g., off-road vehicle usage, fill excavation). Chemical analyses of more than 500 tailings and downstream sediment samples show high concentrations of arsenic and mercury (up to 9000 and 7000 times natural background levels, respectively) near former mill sites, and in downstream environments. Arsenic is present in the tailings in its original form as arsenopyrite (a mineral composed of arsenic, iron, and sulfur); however, high concentrations of arsenic are also hosted by a wide variety of secondary minerals which have formed through years of weathering of arsenopyrite since tailings deposition. Likewise, although it is possible to pan liquid mercury and particles of amalgam from the tailings in many gold districts, much of the mercury is now hosted in secondary phases. Chemistry data indicate that dissolved arsenic concentrations are very high in surface waters influenced by tailings, and often well above guidelines for drinking water quality and the protection of aquatic life. In contrast, dissolved mercury concentrations in surface waters are relatively low even in close proximity to tailings, suggesting that most solid-phase mercury is present in relatively insoluble forms. Detailed studies by the ESS and project partners have also characterized the background levels, chemical forms, mobility, and biological uptake of arsenic and mercury in both freshwater and marine systems.

In March 2005, the ESS presented a summary of project results and recommendations to several deputy ministers with the Province of Nova Scotia, focusing on potential hazards to human health.

Figure 4 Historical gold mine tailings in the intertidal zone of Seal Harbour, Nova Scotia: recent biological studies by Environment Canada and the Royal Military College have shown that soft-shelled clams (*Mya arenaria*) from this site have arsenic concentrations higher than those previously reported in the worldwide scientific literature for mollusks.

Several key issues were highlighted, including the ongoing exposure of recreational users to tailings at several sites (Figure 3), the construction of a cottage on mine tailings, and recent results from EC showing very high levels of arsenic in soft-shelled clams collected from an intertidal tailings flat in Seal Harbour (Figure 4). Nova Scotia quickly established the Historic Gold Mines Advisory Committee (HGMAC) in April 2005, which includes representatives from five provincial and five federal departments. The mandate of the HGMAC is to evaluate the potential ecological and human health risks associated with gold mines throughout Nova Scotia, and to develop recommendations for future management of these tailings sites (http://www.gov.ns.ca/enla/contaminatedsites/goldmines.asp). The committee has issued two press releases warning Nova Scotians of potential health hazards at these mines and advising residents to limit their exposure to tailings. Health warning signs have been posted at the Montague and Goldenville districts and formal human health risk assessments may soon be conducted in these areas. In May 2005, DFO issued a precautionary bivalve shellfish closure for Seal and Isaacs harbours, and members of the HGMAC have carried out additional studies near other gold mines to determine the extent of arsenic and mercury pollution in the coastal zone. Researchers from BIO continue to play an important role in these studies and are providing sound scientific information to help assess and manage risks associated with historical gold mining activities in Nova Scotia.

Arctic Offshore Oil and Gas Exploration Resumes in the Canadian Beaufort Sea

Steve Blasco

Figure 1 SDC hybrid drilling platform on location in the Beaufort Sea at the Devon Paktoa C60 well site (photo courtesy of Devon Canada)

The first Arctic offshore hydrocarbon exploration well in 16 years was drilled on the Canadian Beaufort Shelf from December 2005 through March 2006. The Devon Paktoa C60 well, a successful hydrocarbon discovery, was drilled from a hybrid drilling platform that rested on the seabed in 13 m of water. The platform, referred to as the SDC (Steel Drilling Caisson), was locked into the frigid polar winter ice sheet (Figure 1). The SDC was specially constructed with a reinforced steel hull to resist the pressure of moving sea ice during winter drilling operations.

Seabed geoenvironmental research conducted by NRCan's Geological Survey of Canada (GSC) (Atlantic) at BIO, in collaboration with the Canadian Hydrographic Service (CHS), Devon Canada (a gas production company), and Canadian Seabed Research Ltd (a local geoscience consulting company) contributed to the federal and Inuvialuit regulatory review process of the Paktoa well.

The Canadian Beaufort Shelf, despite significant exploration activity in the 1970s and 1980s, is still a largely unknown Arctic frontier region of Canada. Seabed geoenvironmental conditions have a significant impact on well stability during exploration drilling. Research conducted by GSC Atlantic geoscientists Steve Blasco, Vladimir Kostylev, Kevin MacKillop, Robbie Bennett, Robert Harmes, and Walli Rainey and a CHS survey team lead by Paola Travaglini of the Canadian Centre for Inland Waters in Burlington contributed to the assessment of geohazards and environmental constraints associated with the exploration well.

The research vessel CCGS *Nahidik* (Figure 2) was used as the platform for scientific investigations of the seabed during the August-September survey periods, 2002-2006. A suite of survey equipment, including multibeam and sidescan sonar, sub-bottom profilers, and a digital multichannel streamer, was used to collect 3-D seafloor imagery and acoustic profile data to map geohazards to depths of 100 m below the seabed. Sediment box cores and short gravity cores were

Figure 2 The CCGS *Nahidik* research vessel is 50 m long, has a width of 15 m and draft of 2 m. The CHS multibeam survey launch *Petrel* can be seen on the starboard foredeck.

recovered for sediment property and benthic community composition analyses. A towed camera system provided video imagery of bottom type and distribution of benthic fauna. Survey operations were subject to the threat of encroaching sea ice, sub-zero temperatures, fog, snow, icing, and occasional rough seas driven by strong Arctic winds. Despite these conditions, the research team was successful in achieving survey objectives. Aboriginal participation in the project involved students from northern communities and marine mammal observers onboard during surveys. The research was funded by the GSC, Indian and Northern Affairs Canada, the CHS, and the Panel on Energy Research and Development.

Seabed stability conditions of broad scope were investigated. The presence of high pressure, shallow gas deposits below the seabed posed a problem for drilling activity. Regional investigations of the distribution of active shallow gas vents (Figure 3) and mud volcanoes (Figure 4) indicated the area was prone to shallow gas hazards. The Beaufort Shelf is composed of frozen sediments to depths of 700 m below the sea surface. Drilling through these ice-bearing strata requires the use of chilled drilling muds to avoid melting the sediments surrounding the well casing. The regional geological framework established by the GSC Atlantic indicated that at the Paktoa location the risk of encountering significant frozen sediments was minimal and that trapped shallow gas was a greater hazard. Stable seabed foundation conditions were required for the bottom-founded SDC drilling platform to resist the pressure of moving sea ice and remain on location during drilling operations. Constant reworking of seabed sediments by the passage of ice keels (Figure 5) raised concerns about the strength properties of the marine clays in terms of their ability to provide a stable foundation for the SDC. Strength tests conducted on recovered sediment samples revealed that the

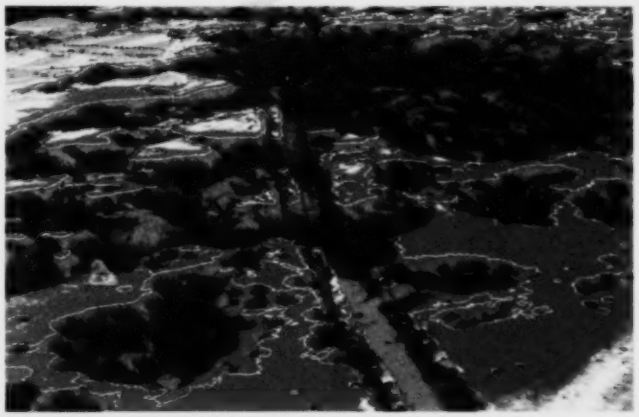


Figure 3 Several hundred gas vent craters (pockmarks) ranging in size from 2 to 20 m wide and 0.5 to 9 m deep are actively venting methane gas which can be observed as a profusion of gas bubbles at sea surface.

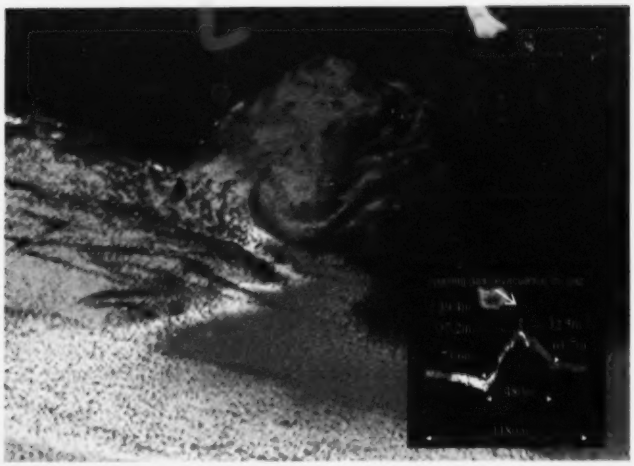


Figure 4 The Kopanoar mud volcano in 50 m of water, actively venting methane gas at its crest

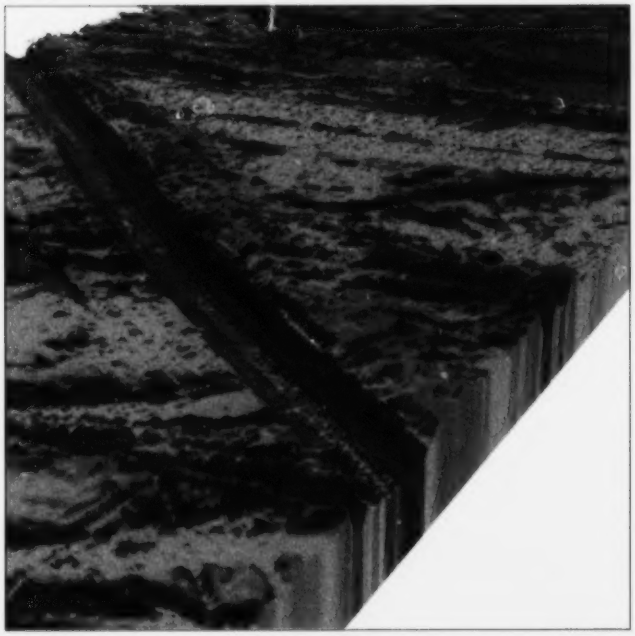


Figure 5 The seabed in 12 m water depth saturated with ice scours created by pressure ridge keels within the moving sea ice

disturbance caused by ice keels did not adversely affect the stability of the foundation. Advice on the nature of these seabed geohazards was provided to the National Energy Board as that agency carried out its regulatory review process.

In addition, the Inuvialuit were concerned that the emplacement of a bottom-founded drilling structure would disturb the benthic habitat and would be an environmental issue. However, constant disturbance of the seabed by ice keels in water depths less than 50 m may prove to be a critical factor limiting the abundance and diversity of the benthic community in shallow waters of the shelf. The widespread reworking of the seabed by pressure ridge ice keels results in a benthic environment more disturbed by the ice than by localized drilling activity.

The regional seabed geoenvironmental investigations conducted by the GSC Atlantic also provided the geohazard framework for the commercial well site investigation conducted by Canadian Seabed Research Ltd. for Devon Canada.

The public interest was well served – the Paktoa C60 well was successfully drilled without incident or negative environmental impact.

An Inshore Shrimp Trap Fishery for Eastern Nova Scotia — The Legacy of Mike Newell

Peter Koeller

Mike Newell (1948-2006)

This article is dedicated to Mike Newell, who died at sea on December 1, 2006, while tending traps in the small, but thriving, shrimp trap fishery he founded.

In the early 1990s, Mike Newell, an inshore fisherman from Canso, Nova Scotia, travelled to New England to research the shrimp trap fishery there. Mike realized that biological and oceanographic conditions off Canso were similar to those off Maine where the winter trap fishery had been conducted along the shore for many years. Fishing had always been Canso's main source of income, and a new inshore shrimp trap fishery would help alleviate the hardships caused by the groundfish fisheries closures. Over the next few years, Mike worked tirelessly to generate interest, obtain funding, and demonstrate the economic viability of shrimp trapping off Canso. This article and a companion scientific paper (also dedicated to Mike) published in the Proceedings of the Nova Scotian Institute of Science, were compiled largely from data which he collected meticulously and shared unconditionally.

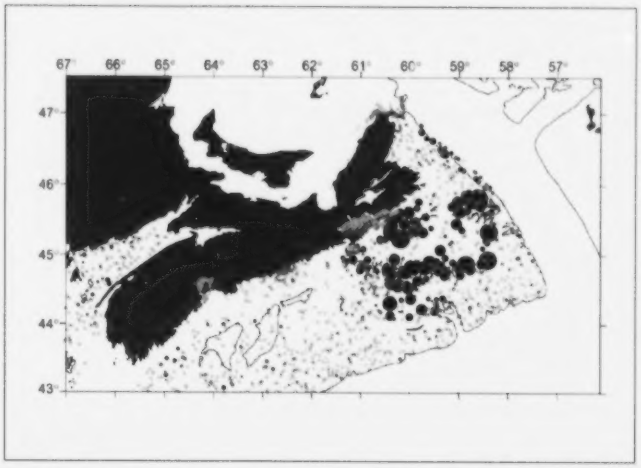
Few people are aware of the daunting bureaucracy a fisherman routinely faces to conduct his business: fishing licences, licence fees, and licence conditions are just the beginning. After he leaves port, to obtain authorization he must "hail out" with information on his planned activities. While fishing, he is subject to boarding and inspection of gear and documentation, or an observer may be aboard for the entire trip. At sea, he collects scientific information in official log books. When returning, he must "hail in" with more information, including details of the catch. He is greeted by a "dockside monitor" who identifies and weighs his catch to the ounce. After the fishing season come the meetings – fishers association meetings, scientific reviews, managerial advisory meetings, ministerial meet-

ings, etc. This is for an existing fishery, with hundreds of years of history. Imagine trying to start a new fishery!

The Atlantic Fisheries Adjustment Program (AFAP) was mostly concerned with finding alternatives to fishing, after the groundfish closures on the eastern Scotian Shelf, but funds were also set aside for "underutilzed" or "developing" species. Most of the prospective candidates were not fish. They included crabs (snow, rock, Jonah, red, spiny, toad), sea cucumbers, whelks, krill, slime eels (sea lamprey), and shrimp. Initially there were two major successes: trapping for snow crab and trawling for shrimp. The main obstacle to developing the shrimp trawl fishery—large bycatches of groundfish under moratorium—was removed by an AFAP project that introduced a fish escape device. But other problems followed, including gear conflicts between the crab trappers and shrimp trawlers on the fishing grounds. Mike knew that any future catches by traps would reduce the shrimp trawler's share of the Total Allowable Catch (TAC), altogether not a good environment in which to start a new fishery.

Mike started with science. After obtaining funds for a trapping project under AFAP, he did what he knew best: he went fishing. He observed and recorded what he caught, when, where, how much, and under what conditions, such as weather and water temperature and depth. He recorded the bycatch, and noticed that catches of shrimp decreased when small female snow crabs entered the traps at certain times of year. From a Department of National Defence submersible, he observed the trapping process first hand, and devised an exclusion device that prevented crabs from entering traps. His data led DFO scientists to use shrimp traps for a female snow crab survey. He realized that shrimp catch rates were related to lunar cycles and tides. He worked also on the various economic problems, including further improving the excellent quality of the trapped product by bringing live shrimp back to port. After several years of experimental fishing, he conclusively demonstrated that a shrimp trap fishery off Canso was economically viable and could result in a permanent, sustainable fishery. With the science in place, he helped secure 10% of the shrimp TAC for the trap fishery. He did all this without ever raising his voice above the level of reason.

The success of trapping off Canso resulted in a flurry of applications for experimental shrimp trapping permits. Because of Mike's success and the ecosystem-friendly trapping gear used, most were granted. Mike shared his knowledge freely, but after many years and thousands of trap hauls between the Bay of Fundy and northern Cape Breton only one other area, Mahone Bay, has been successful in establishing a permanent fishery. It and the fishery off Canso, modest by most standards, are legacies to Mike's vision, hard work, forthrightness, and humility. They were conceived and are conducted in the new spirit of co-operation between government and the fishing industry that places sustainability and ecosystem preservation among their main concerns.



Shrimp catches from DFO survey trawls (1999-2006, in blue) and DFO-industry trap hauls (1996-2006, in green). Larger circles indicate larger catches. Open blue circles indicate no shrimp were caught in trawls; red circles indicate none were caught in traps.

REFERENCE

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Bridging Disciplines – The Power of a Shared Approach

Wendy Woodford, Carrie MacIsaac, Bruce Anderson, and Richard MacDougall

The Canadian Hydrographic Service (CHS) and the Office of Coast Guard Survey for the United States (US) are responsible for hydrographic surveying and nautical charting in our respective countries. With similar mandates which include providing hydrographic services in boundary waters, there is obvious value in sharing knowledge about standards, policy development, new technology, and applications supported by hydrographic data. In the mid-1990s, it was decided that, rather than each country holding its own annual conference, hydrographic conferences would alternate between Canada and the US to further enhance this sharing of knowledge.

The CHS and the Canadian Hydrographic Association (CHA) hosted the Canadian Hydrographic Conference (CHC 2006) at the Westin Nova Scotian Hotel in Halifax, June 5-9. The event, which attracted over 440 delegates and 42 exhibitors from 16 countries, was co-chaired by Michael Lamplugh and Wendy Woodford, with assistance from Carrie MacIsaac (all from the CHS at BIO), a steering committee representing industry and several government departments,

and numerous volunteers. The diverse group of delegates, including many from outside the hydrography field and comprising a broad cross-section of scientists and other professionals active in all aspects of ocean science and governance, exchanged information and shared ideas, concerns, and solutions. A special reduced registration fee for retired hydrographers provided an opportunity for a number of former colleagues to attend, renew old acquaintances, and greatly enrich the corporate and scientific knowledge base available during the discussions.

The conference theme was *Bridging Disciplines – The Power of a Shared Approach*. Presenters focused not only on hydrographic techniques and technology, but also on the application of hydrographic science and data to every aspect of ocean science and ocean resource management. The program comprised a workshop and training segment, technical sessions, exhibits, special events, and social activities.

WORKSHOPS/TRAINING

Day One was devoted to technical workshops, in which approximately 100 delegates participated. Following are the workshops:

CARIS - "Ping to Chart" Tour 2006
CARIS is a Canadian company that is a world leader in digital charting software.

KLEIN ASSOCIATES INC. – SideScan Workshop
Klein Associates Inc. is a pioneer in the development of sidescan sonar, sub-bottom profilers, and related instruments and accessories for undersea search and survey.

HYPACK MAX Workshop by HYPACK, Inc.
HYPACK is powerful hydrographic software which is used throughout the world for survey design, data collection, graphical editing, plotting, volume computations, surface modelling, and contouring.

ICAN-QPS – Sounding to Chart in 24 Hours — or Less
QPS provides practical, easy-to-use, software tools that cover the full spectrum – from data acquisition, through real-time pre-processing and post-processing validation, to chart production.

Chesapeake Technology Inc. – SonarWiz.MAP
Chesapeake demonstrated how to get the most out of sidescan and sub-bottom survey: pre-, post-, and real-time sidescan and sub-buttom survey acquisition and analysis techniques.

The Fifth International Discussion Group Meeting on Uncertainty Management in Hydrography
Chair: Dr. David Wells, CHS Newfoundland

Data Management Infrastructures
Chair: Dale Nicholson, CHS Atlantic at BIO

TECHNICAL SESSIONS

The technical sessions began on June 6, with Larry Murray, DFO Deputy Minister, officially opening the conference. Dr. Savithri Narayanan, Dominion Hydrographer and Director General of Ocean Science and the CHS, welcomed delegates on behalf of the CHS, while Captain Steven Barnum, Director of Coast Surveys, National Ocean Survey with the National Oceanic and Atmospheric Administration (NOAA), delivered opening remarks on behalf of NOAA.

Captain Julian Goodyear addresses the Canadian Hydrography Conference 2006.

Julian Goodyear, DFO Regional Science Director, Newfoundland Region, gave the keynote address. Drawing on his career experience as a hydrographer, ship's captain, Regional Director of the CHS and the Canadian Coast Guard, and in his present post, Captain Goodyear's talk focused on the role of hydrography and the benefits of a shared approach.

The technical program was organized in single sessions to eliminate the conflicts created by parallel sessions. Over the next three days, papers were presented in the following sessions:

Sovereignty: Law of the Sea
Chair: Dr. Richard Haworth, NRCAN (retired)

Ocean Management: Application of Seafloor Mapping
Chair: Dr. Dick Pickrill, NRCAN

Products and Services: 21st Century Products and Data
Chair: Dr. Wyn Williams, United Kingdom Hydrographic Office

Security: Marine Ports and Harbours
Chair: Dr. Ross Graham, Defence Research and Development Canada

Transportation: Modern Charting Requirements (including the Arctic)
Chair: Captain Julian Goodyear, DFO

Hazards: Emergency Response to Environmental Events
Chair: Commander Wayne Hamilton, Canadian Navy (retired)

Oceanography: Water Levels and Ocean Modelling
Chair: Dr. Savi Narayanan, CHS

Fisheries: Seabed Classification and Habitat Mapping using Multibeam Methodologies
Chair: Dr. John Anderson, DFO

Marine Archaeology: The Application of Hydrographic Techniques to Historical and Paleo-research
Chair: Ken McMillan, McQuest Marine Sciences

Technology: Selected Advances in Hardware and Software
Chair: Andrew Armstrong, NOAA/University of New Hampshire

Papers and presentations are available on the CHC 2006 website (www.chc2006.ca).

EXHIBITORS

The involvement of exhibitors contributed to the exchange of knowledge and to the social programme. In the sold-out display area, 42 exhibitors demonstrated the latest in equipment and services related to hydrography. The well attended tradeshow was followed by the always popular Exhibitors' Beer Social with live music and prize draws. The list of exhibitors is available on the conference website.

SPECIAL EVENTS

The conference provided the opportunity for hydrography-related special events. Canada unveiled the first Canadian chart (Chart 1316, Québéc) produced by the CARIS Hydrographic Production Database (HPD). The Chilean delegation also was recognized for having produced a chart using the HPD.

A meeting of the United States-Canada Hydrographic Commission was held, with heads of delegations from other hydrographic organizations invited as observers. Guests included Admiral Maratos, President of the International Hydrographic Bureau, and Dr. Wyn Williams, United Kingdom Hydrographic Office. Several presentations were made to Dr. Williams to commemorate his upcoming retirement.

The Association of Canada Lands Surveyors and the CHA launched the 3rd edition of the book *Canadian Offshore: Jurisdiction, Rights and Management*, a reference for hydrography and offshore legal rights in Canadian waters.

SOCIAL ACTIVITIES

The legendary Maritime hospitality and cuisine were evident throughout the social events, to the delight of the many hungry and thirsty delegates, exhibitors, and their guests. Kongsberg Maritime sponsored the CHC 2006 Icebreaker event at the Maritime Museum of the Atlantic. Throughout the evening, delegates browsed the museum exhibits, which include a display on the *Titanic* sinking and another on the Halifax Explosion, and explored the Halifax waterfront. Many enjoyed tours of the retired survey ship, CSS *Acadia*, now a museum exhibit, and the active survey vessel, CCGS *Matthew*.

On Thursday, delegates and their guests attended an evening reception and Nova Scotia lobster supper at historic Pier 21 and Pier 22 on the Halifax harbour. The event featured a band and dancing. Several visiting delegates were initiated into the Order of the Bluenose, donning sou'westers and blue noses and "enjoying" a once-in-a-lifetime opportunity to kiss a mackerel.

Figure 3 Delegates enjoy a reception at the Maritime Museum of the Atlantic.

Hydrographic survey vessels, the CSS *Acadia* (left) and the CCGS *Matthew*

The CHC program also included activities that allowed delegates' spouses to experience our local culture and to visit such attractions as the Halifax waterfront, Peggy's Cove, Prospect, Mahone Bay, and Lunenburg.

CLOSING

The program concluded at noon on Friday, with Dr. David Wells of the universities of New Brunswick and Southern Mississippi presenting the conference overview and closing remarks.

The conference was successful in bringing together diverse users who depend on hydrographic data to deliver their respective mandates. New possibilities for sharing of data and expertise were identified. These can be explored as we move forward with more integrated management of our maritime resources. The science of hydrography, while essential to safe maritime transportation, is yet a much broader field. It plays roles in each of the conference session themes and touches all citizens in some way.

The next North American hydrographic conference will be the US Hydrographic Conference scheduled for Norfolk, Virginia, May 14-17, 2007, followed by the Canadian Hydrographic Conference in Victoria, British Columbia, May 4-8, 2008.

OCEANS AND AQUATIC MANAGEMENT

Introducing the Environmental Assessment and Major Projects Division

Ted Potter, Ted Currie, Mark McLean, and Reg Sweeney

The Environmental Assessment and Major Projects Division (EA&MPD) is part of the Oceans and Habitat Branch of DFO and plays an integral role in fish habitat protection in Canada. DFO's Fish Habitat Management Program has a broad mandate to conserve and protect fish habitat. Delivery of the program includes the application of the *Fisheries Act*, the *Canadian Environmental Assessment Act*, and the *Species at Risk Act* (SARA) to a variety of projects that have the potential to affect a wide range of individuals, businesses, and communities across the Maritimes Region.

The EA&MPD was formed nationally in 2005 to improve predictability, transparency, and timeliness of environmental assessment reviews for major projects. The new division is responsible for the conduct of environmental assessments of all major projects proposed in the Maritimes Region, including undertakings that are complex, multi-jurisdictional, and/or have nationally significant socio-economic implications. Comprising a manager, two environmental analysts, and an administrative assistant, the EA&MPD team has a broad depth of experience and the capacity to respond to most of DFO's complex environmental assessment requirements.

Under the *Canadian Environmental Assessment Act*, an environmental assessment is required prior to *Fisheries Act* authorizations. The most frequently used type of authorization that initiates, or triggers, the *Canadian Environmental Assessment Act* is subsection 35(2) relating to the harmful alteration, disruption, or destruction of fish habitat. As a requirement of the *Canadian Environmental Assessment Act*, DFO must evaluate all areas of federal environmental responsibility before *Fisheries Act* authorization can be considered. For projects that do not require this authorization, DFO is sometimes required to participate as an expert in the environmental assessment.

The EA&MPD works in close partnership with many other groups within DFO, such as the Habitat Protection and Sustainable Development Division and Science Branch, to evaluate undertakings with a potential to result in adverse impacts on fish and fish habitats. Excellent communication within the department is an essential element of the EA&MPD's operations to ensure the public and proponents receive a common message.

In addition to the coordinating role within DFO, EA&MPD works in close collaboration with other federal and provincia departments during the environmental assessment reviews. Ofte major projects require an environmental assessment by severa federal departments and the affected province; by conducting th review through a coordinated effort, duplication is minimized.

Two current projects being reviewed by EA&MPD include th Whites Point Quarry and Marine Terminal, and the Brunswic Pipeline.

The Whites Point Quarry and Marine Terminal is a propose basalt quarry, processing facility, and marine terminal located o Digby Neck in Digby County, Nova Scotia. Quarrying is propose to take place on 120 hectares of land, with production expected t be two million tonnes of aggregate per year. Approximately 40,00 tonnes of aggregate would be produced for loading each week. A joint federal-provincial review panel has been established to eval uate the potential environmental impacts of the proposed projec and report back to both levels of government. The EA&MPD i responsible for coordinating DFO's involvement in this revie process, including evaluating the 3,000-page environmenta impact statement, reviewing more than 250 submissions from th public and other government departments, providing informatio to the panel, coordinating DFO's involvement in the public hear ings, and leading the Government of Canada's response to th panel report.

Emera Brunswick Pipeline Company Ltd. has proposed th construction of a high volume pipeline to convey natural gas fro the Canaport facility located near Saint John, New Brunswick, t US markets. The Brunswick Pipeline will be 762 mm (30 inches in diameter, approximately 145 km long, and will require th construction of approximately 120 watercourse crossings. It i anticipated that some of the complex watercourse crossings wil require *Fisheries Act* authorizations. The project will also requir approval from the National Energy Board, but first must receiv approval under the *Canadian Environmental Assessment Act*. Th EA&MPD will represent DFO during all phases of the revie process, including evaluating environmental reports, reviewing th statements of interveners in the process, providing information t

assist the panel, reviewing panel recommendations, and preparing a departmental position report on the level of significance of environmental effects.

Since its creation in 2005, the EA&MPD has provided a single point of contact within DFO for proponents complying with legal requirements under the *Fisheries Act* and the *Canadian Environmental Assessment Act*. The team has many years of practical experience in dealing with complicated environmental reviews and can work in partnership with internal and external partners to deliver the program in a timely and efficient manner. Major projects anticipated in the near future include tidal power proposals, coal-bed methane extraction, oil refineries, LNG facilities, and major mining projects.

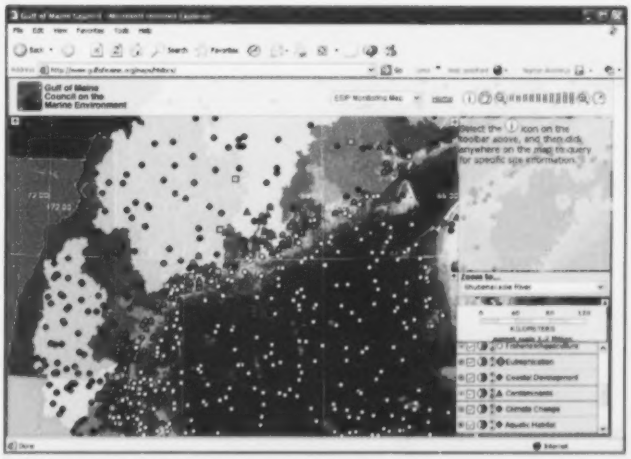
Further information about the EA&MPD regional programs may be obtained from the Regional Manager's office at BIO at (902) 426-2155 or by visiting the national EA&MPD website at (http://oceans.ncr.dfo-mpo.gc.ca/habitat/eamp/default_e.asp).

Collaboration between Canada and the United States in the Gulf of Maine

Anita Hamilton and Maxine Westhead

A marine boundary between Canada (CA) and United States (US), known as the Hague Line (1984), divides the Gulf of Maine and Georges Bank. The Maritimes Region of DFO is ideally suited to engage in collaborative activity with the US in this area due to the region's proximity to the US east coast. The shared waters of the Gulf of Maine, several transboundary fish stocks, large US markets utilized by Canadian fishermen, and the longstanding connections between research institutions all make this region an ideal focus of CA-US relationships, both formal and informal.

Since the passage of Canada's *Oceans Act* (1997) and the subsequent release of the Oceans Strategy and Oceans Action Plan, the concept of integrated oceans management has been increasingly evolving. At the same time, our US partners have completed their Oceans Commission Report and the Bush Administration's Oceans Action Plan. All of these efforts call for a broader scope and an ecosystem-based approach to oceans management, both of which are being addressed in the following collaborative activities by CA and the US in the Gulf of Maine.



ESIP map showing Gulf of Maine monitoring sites

The CA-US Steering Committee

Since 1984, the CA/US Steering Committee has been the primary mechanism that exists for the federal management of transboundary fish stocks in Gulf of Maine waters. Working closely with the fishing industries of both countries, this group is co-chaired by the regional heads of DFO and the National Marine Fisheries Service (Northeastern Region), and jointly manages the three groundfish stocks of cod, haddock, and yellowtail flounder in shared waters. In response to the new ecosystem-based policy thrusts, three new working groups are now supporting this committee by discussing other transboundary issues – habitat, species at risk, and oceans. This allows the committee to address broader oceans ecosystem considerations. Ultimately, these bilateral working groups, each co-chaired by a Canadian and U.S. representative, will expand existing species-

A self-regulating tidal gate that allows fish passage – photo courtesy of Tony Bowron

based fisheries management to be more inclusive and responsive to the broader oceans management community.

In particular, the Oceans Working Group is developing a joint Ecosystem Overview and Assessment Report (EOAR) that will bring together the current scientific knowledge of the Gulf of Maine ecosystem. The peer-reviewed report will provide integrated scientific knowledge needed to support the development of ecosystem objectives and the advancement of integrated oceans management. The EOAR will be used by oceans managers, regional governance and research networks, non-government organizations, and others.

The Gulf of Maine Council

Collaboration also occurs through the Gulf of Maine Council on the Marine Environment (GOMC). It is estimated that 80% of marine pollution comes from land-based sources. This highlights the importance of land use and watershed planning, thus involving the provinces and states in oceans management. The GOMC was formed in 1989 by the governors of Massachusetts, New Hampshire, and Maine and the premiers of New Brunswick and Nova Scotia as a regional forum to exchange information and engage in long-term planning to maintain and enhance environmental quality in the Gulf of Maine.

Committees are responsible for implementing the goals of the GOMC's Action Plan. One such committee is the Ecosystem Indicator Partnership (ESIP), which defines indicators as "quantitative or qualitative measures that provide information about the status of or changes in natural, cultural, and economic aspects of an ecosystem." ESIP focuses on six indicator theme areas: coastal development, contaminants and pathogens, eutrophication (overgrowth),

Grade 11 students from Massachusetts, having fun in the Bay of Fundy mud – photo courtesy of Maxine Westhead

Cross-border Education

An initiative that fosters education and communication about the Gulf of Maine has been underway for the past four years. Students from the Essex Agricultural and Technical High School in Massachusetts have toured the Bay of Fundy area to learn about Canada's ecological connections to the US. Their visits include a guided walk on the mudflats of Evangeline Beach, where they learn about shorebirds and migration routes, marine ecology, the uniqueness of the Bay of Fundy, and our distinct and critical ecological connections.

A restored tidal marsh in the Gulf of Maine – photo courtesy of Tony Bowron

aquatic habitat, fisheries and aquaculture, and climate change. Their gulf-wide indicator and reporting structure is designed to create relevant products and environmental report cards for users, developed through an open, science-based process. The first report card for the Gulf of Maine region, *Tides of Change*, was released in 2004 for the Gulf of Maine Summit. An interactive website showing monitoring locations throughout the region was released in October 2006 (http://www.gulfofmaine.org/esip).

The Habitat Committee of the GOMC is composed of four subcommittees, one of which, Habitat Restoration, is concerned with fish passage—a serious issue affecting the productive capacity of aquatic systems. Tidal barriers and interruptions to natural watercourse flows contribute to a loss of habitat for fish, especially diadromous and coastal migratory species. Physical barriers include full and partial blockages of aquatic systems by dams, causeways, breakwaters, and culverts. Habitat managers seek to eliminate these barriers by designing physical structures to span waterways. In some cases, removal of barriers or installation of spanning structures is not possible and technologies are being investigated that will satisfy historic or cultural requirements and also assure fish passage.

DFO is represented on the Habitat Restoration Subcommittee by the Habitat Protection and Sustainable Development Division (HPSDD) of the Oceans and Habitat Branch. In June 2006, a workshop to review technologies being used to address tidal barriers and interruptions in the Gulf of Maine states was organized through the HPSDD and the National Oceanic and Atmospheric Administration (NOAA) Restoration Center in Gloucester, Massachusetts. The workshop looked at projects using a variety of techniques that have been proposed, are underway, or have been completed. Staff from NOAA and DFO and members of non-government organizations that are addressing barrier issues attended the 2½ day workshop. Workshop participants had the opportunity to assess projects, troubleshoot problems, and discuss applications of various technologies and their viability in the Bay of Fundy-Gulf of Maine marine, estuarine, and freshwater systems. The exchange of ideas and discussion of the logistics of these projects contribute to a better understanding of the dynamics of these unique Atlantic ecosystems and how development projects can be undertaken in an environmentally sustainable manner.

Recent CA-US collaboration in the Habitat Restoration Subcommittee will result in a document detailing protocols for monitoring restored environments in transition from restricted to open fish passage. This document will be a product of collaboration among experts in the fields of hydrology, sedimentology, fish biology, instream biota, wetlands, and riparian areas. The protocols presented will adopt established methods and present them as a package for government and non-government organizations. Further, the document will offer a methodology to respond to questions concerning the effectiveness of habitat restoration following barrier removals. It is anticipated that these protocols will be used within the Maritimes Region to contribute to the methods employed by habitat managers and proponents to assess the status of aquatic systems before development occurs and during and/or following project completion, and to monitor the effectiveness of restoration projects.

The Gulf of Maine represents a unique biological and hydrological system, and the GOMC is an innovative collaborative approach to environmental and fisheries management. International efforts towards protection and sustainable development in the Gulf of Maine continue to be supported by a diverse community of government and non-government organizations using science, negotiation, and co-operation as management tools.

Spotlight on the *Species at Risk Act* Recovery Planning Progress

Diane Beanlands, Lynn Cullen, Tracie Eisener, Katie Kinnaird, Paul Macnab, Chastity McKinnon, Arran McPherson, Shane O'Neil, Kimberly Robichaud-LeBlanc, Heidi Schaefer, and Cindy Webster

The *Species at Risk Act* (SARA) was designed as a tool to ensure the conservation and protection of biodiversity in Canada. It provides a framework for action across the country to ensure the survival and recovery of wildlife species at risk and the protection of our natural heritage. The SARA Coordination Office, located at BIO, provides coordination, advice, and assistance to DFO sectors with SARA responsibilities in the Maritimes Region. In 2006, regional staff made important contributions to DFO Maritimes Region's SARA activities. Key recovery planning activities are highlighted below.

After a species is listed under SARA, the recovery planning process begins. There are two parts to this process for extirpated, endangered, and threatened species: a Recovery Strategy (identifies threats to the species and describes recovery objectives) and an Action Plan (details activities that will be carried out to promote the species' recovery). Recovery Strategies and Action Plans are developed in collaboration and/or consultation with scientists, community members, and other stakeholders, often by forming a Recovery Team. When approved by DFO, Recovery Strategies are published on the Public Registry for a 60-day period for public comment before finalization.

Five Recovery Teams have been formed in the Maritimes Region: the North Atlantic right whale, Inner Bay of Fundy Atlantic salmon, Atlantic whitefish, Atlantic leatherback turtle, and Lake Utopia dwarf smelt Recovery Teams. Recovery Team meetings were held throughout 2006, resulting in proposed Recovery Strategies being posted on the Public Registry for two species: the Atlantic leatherback turtle and the Atlantic whitefish. Strategies for the other species are in various stages of development or review and an Action Plan is under development for the Atlantic whitefish.

The North Atlantic Right Whale

Inserting hydro-acoustic tags in Atlantic whitefish

Release of Atlantic whitefish

In 2006, three age classes of endangered Atlantic whitefish reared in captivity at the Mersey Biodiversity Facility were released into Anderson Lake in Dartmouth, Nova Scotia. This recovery action was in partnership with local landowners and had support from the Department of National Defence and the Interdepartmental Recovery Fund. The initiative, recommended by the Atlantic Whitefish Recovery Team, is part of a three-year trial to establish a backup population of Atlantic whitefish, in an attempt to minimize its risk of extinction. The trial also provides valuable information on the species via unique signals transmitted through hydro-acoustic tags inserted in the fish during a brief surgery in April. The Atlantic whitefish is an endemic species in Canada, found only in the Petite Rivière watershed in southwestern Nova Scotia. It is listed under SARA as endangered, which means it is at serious risk of becoming extinct.

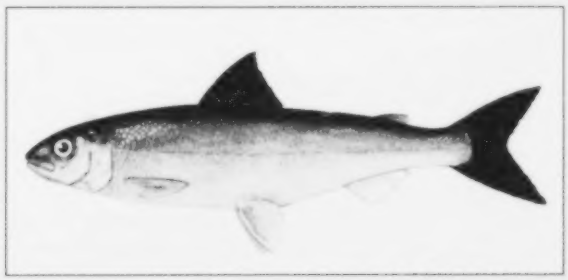
Spawning Atlantic salmon

Under SARA, Management Plans must be developed for species of special concern. Management Plans set goals for maintaining sustainable population levels of one or more species that is particularly sensitive to environmental factors, but which is not in danger of becoming extinct. A Management Plan is currently being developed for the yellow lampmussel. For more information about SARA-related activities, refer to the website, (www.sararegistry.gc.ca).

Leatherback turtle

A Bottlenose Whale of a Time at BIO!

A new exhibit of The Gully Marine Protected Area in a BIO mini-theatre is the only permanent display of The Gully science and educational material for the general public. It describes the ecosystem and its species with a specific focus on Northern bottlenose whales (endangered) and deep sea corals, and even showcases a large Northern bottlenose whale model. The exhibit also features a 3-dimensional model of The Gully, demonstrating a prototype application of digital data consistent with the long tradition of BIO innovation in hydrographic data handling and seabed visualization. This key stop on the BIO tour route is seen by hundreds of students and visitors a year.



Something Fishy at *Hinterland Who's Who*

In April, Atlantic whitefish starred in a *Hinterland's Who's Who* (HWW) vignette, filmed at the Petite Rivière watershed near Bridgewater and at the Mersey Biodiversity Facility. This marked the first time in the 45-year history of HWW, an organization that produces wildlife commercials for public education, that a fish was featured. This, their first high-definition film, was launched in Lunenburg at the Fisheries Museum of the Atlantic in September. For more information or to see the video visit: (www.hww.ca/media.asp).

TECHNICAL SUPPORT

Research Voyages in 2006

Donald Belliveau

Researchers at BIO utilize the following research vessels based at the Institute and operated by the Canadian Coast Guard (CCG), Maritimes Region:

CCGS *Alfred Needler*, a 50 m offshore fisheries research trawler;
CCGS *Hudson*, a 90 m offshore research and survey vessel;
CCGS *Matthew*, a 50 m coastal research and survey vessel.

In addition, BIO scientists conduct field programs on CCG research vessels from other DFO regions, vessels of opportunity (e.g., CCG buoy tenders and icebreakers, commercial fishing ships, and survey ships), and research vessels of other countries. The CCGS *Creed*, based in Quebec Region, was used by both the Canadian Hydrographic Service (CHS) and NRCan for multibeam survey work in the Gulf of St. Lawrence and Bay of Fundy. Surveys normally conducted on the CCGS *J.L. Hart*, a 20 m inshore research vessel, were conducted on a series of charter vessels in 2006 because the *Hart* was removed from service and the replacement vessel is not yet available. One cruise took place this summer on the CCGS *Wilfred Grenfell* out of St. John's. The Department of National Defence (DND) Remotely Operated Vehicle (ROV) Deep Submergence Intervention System (DSIS), was deployed to evaluate its ability to work from a CCG platform. DFO's Science Branch participated in the evaluation when the system was used to recover a lost mooring on the Scotian Shelf and to conduct several deep dives in The Gully.

The CCGS *Alfred Needler*'s principal role is stock assessment surveys. Data collected during the annual multi-species ecosystem surveys are a primary source of information for DFO fish and invertebrate stock assessments conducted in the Atlantic zone. The data are used also for fisheries research programs. The February and March annual winter ecosystem surveys on Georges Bank and the Scotian Shelf were completed by the *Needler* this year with the loss of some time on Georges Bank due to continuing winch problems. These cruises also carried out the comparative fishing program with the CCGS *Teleost*. A Browns Bank research cruise for Maritimes Region's Population Ecology Division was completed. The *Needler* was sent to Newfoundland to help with surveys in June. Delays in the annual refit led to the loss of the annual fisheries observer training cruise. The annual summer Bay of Fundy and Scotian Shelf surveys were completed in July, followed by the Gulf of St. Lawrence fish disease survey. The *Needler* returned to BIO on August 11 to prepare for her Transitional Life Extension, an extended refit that will upgrade the vessel's systems as well as add considerable oceanographic science capabilities in preparation for the planned reduction from three to two trawlers.

The CCGS *Hudson* started her year two weeks later than planned due to crane overhaul/certification problems. The first cruise was for the annual spring Atlantic Zone Monitoring Program (AZMP). This cruise collects data on water properties, temperature, salinity, nutrients, dissolved oxygen, and plankton biomass for the annual State of the Ocean Report and focussed research projects. The second cruise serviced moorings in Orphan Basin and Flemish Pass off Newfoundland. The vessel then sailed to the Labrador Sea to service oceanographic moorings and collect conductivity, temperature, and depth data in oceanographic survey operations, as part of Canada's contribution to global climate studies. The *Hudson* then went to the Hibernia offshore oil field to investigate the impacts of "produced" water on the environment around the platform. "Produced" water is recovered with the oil as it is brought from deep underground. After returning from Hibernia, the *Hudson* sailed to the Bay of Fundy to continue a multi-year project studying biodiversity in the Gulf of Maine Discovery Corridor. This corridor extends from the coast of New Brunswick/Maine across Georges Bank and out past the shelf break. This year, ROPOS—the Remotely Operated Platform for Oceanographic Science, a 6000 m capable ROV—was installed on the *Hudson* for the first time. With ROPOS, researchers were able to explore parts of the Discovery Corridor with video and still imagery and to collect biological and geological samples under operator control. NRCan used the *Hudson* in August and September for a series of cruises covering parts of the Scotian Shelf, the Grand Banks, northern Newfoundland, and the Labrador coast. They conducted sidescan surveys, piston coring, bottom photography, grab sampling, and seismics for geophysical research. The Maritimes Region fall AZMP cruise was conducted in October. From late October to early

December, oceanographers from the Institut Maurice Lamontagne in Quebec Region and the Northwest Atlantic Fisheries Centre in St. John's conducted cruises to obtain the autumn AZMP physical and biological oceanographic dataset and the Gulf of St. Lawrence ice forecast dataset. The season concluded December 7 when the ship was docked at BIO for the winter. Because of propulsion problems, the last planned trip of the year to recover moorings in The Gully was moved to the CCGS *Sir William Alexander*.

The CCGS *Matthew* is primarily a hydrographic vessel which can carry two hydrographic launches and conduct surveys with its high resolution Kongsberg EM710 multibeam system. Upgrades to the receiver electronics of the EM710 multibeam system doubled the resolution, providing up to 400 soundings across the swath. After completion of upgrades to its fire extinguishing system, the *Matthew* began its field season in mid-May with a trip to Placentia Bay to continue work started in 2004 for NRCan. After a short stay at BIO in early June where she was a star exhibit at the Canadian Hydrographic Conference, the *Matthew* moved to the north coast of Newfoundland for bottom surveys and, using an additional advantage of the new multibeam system, simultaneously collected information on the fish in the water column as part of a fisheries ecology research program. The *Matthew* headed for the Labrador coast in July for NRCan to conduct a surficial geology survey near Makkovik. The ship spent August and early September continuing multibeam surveys for a safe navigation corridor up the Labrador coast, returned to Placentia Bay in mid-September, and moved to the western Northumberland Strait in late September to conduct ecosystem management surveys. NRCan staff used the vessel in October for a survey in the Gulf of St. Lawrence, conducting geophysical research including

The ROPOS is deployed from the *Hudson* for exploration in the Discovery Corridor.

The *Matthew* in Grand Bruit, a village with no road access on the south coast of Newfoundland – photo courtesy of Michael Lamplugh

seismics, grab samples, and gravity coring. After a brief visit to Lunenburg to recover moorings, the *Matthew* finished the year in St. Margaret's Bay and Halifax Harbour approaches, while the CHS conducted hydrographic surveys with DND. The *Matthew* returned to BIO Nov 23.

Replacement of our ageing scientific research fleet is a high priority. Plans are underway to replace the *J.L. Hart*; preliminary design work was started in 2006, with detailed design and build to take place after that. Two replacement trawlers, one for each of the east and west coasts, were announced in the spring 2005 federal budget. Contracts have been let to start the preliminary design, with delivery planned for 2010/2011.

Marine Engineering Contributions to Science at BIO

Andrew Muise

The Marine Engineering section of the Canadian Coast Guard's (CCG) Integrated Technical Services Branch, is located in the Vulcan Building at BIO. The section is supervised by the Supervisor Vessel Support – BIO. The facilities under that supervision include the Carpenter Shop, Diesel Shop, and the co-located Boat Shop and Canopy Group.

The primary responsibilities of Marine Engineering are to provide the BIO science community with material handling services through the use of our mobile crane, two forklift trucks, a tow vehicle, and skid-steer and front-end loaders; the preparation of electro-hydraulic winches and associated pumping units for deployment on research vessels and on vessels of opportunity; maintenance and repair services for small craft such as the Canadian Hydrographic Service (CHS) survey launches; maintenance and repair services for the scientific portable labs (modified twenty-foot containers); and basic carpentry services for the fabrication of packing crates, work tables/benches used onboard the research vessels, and basic display cases.

Figure 1 The *Pelican*

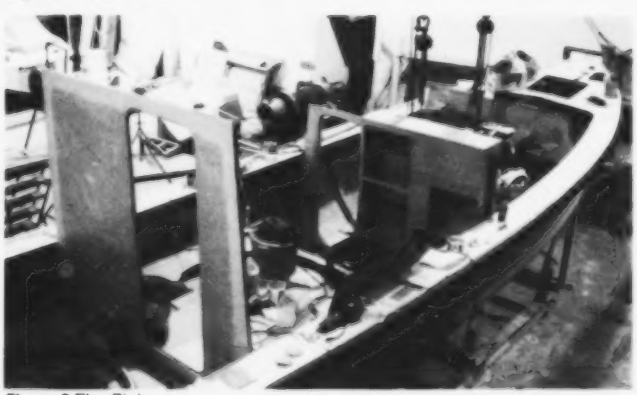


Figure 2 The *Pipit*

During 2006, the section was involved in the renovations to the CHS survey launch *Pelican* (Figure 1). This small craft was completely renovated, and the hull was fitted with two external pods to facilitate the installation of the program multibeam and single-beam transducers. Most work on this small craft was completed in 2005; however, once the *Pelican* returned to BIO, it was outfitted with the program equipment and made ready for deployment. Because of a problem with the launch's stability after the installation of the program equipment, ballast had to be put into the launch to improve her stability. This resulted in the launch being too heavy to be carried on the mother vessel CCGS *Matthew* so the *Pelican* was used this past operational

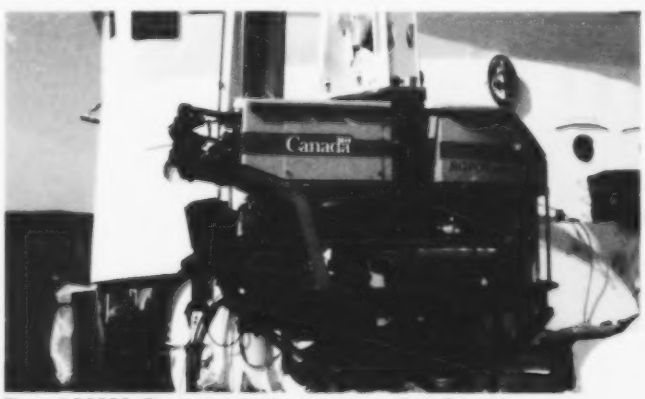


Figure 3 ROPOS *(Photo reproduction is courtesy of the Canadian Scientific Submersible Facility.)*

season as a field service launch transported either by water or road to locations throughout the Maritimes Region of DFO.

In early 2006, similar contracted work was performed for the rebuilding of the *Pelican*'s sister launch, the *Pipit* (Figure 2). The intent is to correct the stability and the weight issues experienced with the *Pelican*. The *Pipit* renovation project is expected to be completed in 2007.

Marine Engineering also worked with the Ocean Sciences Division, from late winter into early summer, to plan for the initial installation of ROPOS on the CCGS *Hudson*. This remotely operated vehicle was deployed in the Gulf of Maine conducting surveys to monitor changes in coral abundance within several coral conservation areas. The section also provided material handling resources to insure that all equipment associated with the installation of ROPOS on CCGS *Hudson* was loaded during the deployment phase and removed during the de-mobilization phase.

BIO Redevelopment – Becoming a Reality

Brian Thompson

Throughout 2006, the **Level II laboratory** was the major focus of the BIO Redevelopment Program. By year's end the facility was 90% complete, with the building envelope, electrical and mechanical systems, interior walls, ceilings, windows, doors, and flooring in place. As well, freezer units had been installed on the second floor. Although it had been anticipated that the casework including lab benches would be completed in 2006, delays were encountered and that work was deferred until 2007. Moving biological samples and chemicals into the 2nd floor storage areas and setting up workstations were also rescheduled. The delay was in the best interest of matching available lab units to specific Science programs, though cost increases also set back the completion.

Levels 3, 4, and 5 of the facility comprise a total of 14 single, 21 double, 4 triple, and 1 quadruple module labs. The main electrical room is situated on the first floor while the top floor or penthouse accommodates the building's air handling system. The new lab will be physically connected to the van Steenburgh Building at the 2nd floor level. Access to the Strickland Building and the jetties is via an enclosed pedway. Besides its high level of functionality, the new facility will provide an aesthetically pleasing work environment. At all levels, the western side of the building offers outstanding views of the Bedford Basin while the eastern face, with its cantilevered corridors, overlooks the naturally wooded area of the BIO property.

During 2006, significant progress was made on the renovation design for the **van Steenburgh Building**, with final design drawings developed to the 99% stage for the main building project. Subsidiary phases, such as relocation of shops and preparation of swing space in the Vulcan Building, also were started. Because of the domino-like relationship among the BIO building projects, the actual tendering and construction of the van Steenburgh Building must wait until the lab building is completed.

As well, several smaller but important projects were undertaken at BIO in 2006. Examples include wall tie, lintel, and masonry repairs to the southern side of the **Murray Building** and along the eastern side of the **Holland Building**.

Typical lab room

Cantilevered lookout on eastern side of new lab building

Individual lab entrances and work station area on western side of the Level II Laboratory

Holland building masonry repairs

RETROSPECTIVE 2006

New Initiatives and Developments

In 2005, DFO and the Chilean Sub-secretariat of Fisheries (SUBPESCA) signed an **agreement on Environmental Cooperation for Sustainable Aquaculture**. This was in recognition that failure to address issues of public confidence associated with aquaculture production has led to lost economic, social, and environmental opportunities for aquaculture-producing nations. The agreement involved a one-year exchange of personnel; representing DFO were Allison Webb (Pacific Region) and Joey Crocker (BIO). The agreement also provided for the facilitation of an international workshop to review respective environmental legislation and facilitate dialogue on management strategies and technology available to promote sustainable aquaculture production. The workshop was co-hosted by DFO and SUBPESCA in Puerto Montt, Chile, March 20-21, on the margins of *AquaSur 2006*, the Chilean international aquaculture trade show. The workshop was attended by ministerial representatives from Norway, Indonesia, Peru, Canada, and Chile

Tim Milligan and Paul Hill (behind davit) are deploying an instrument package from the Gunningsville bridge in Moncton, New Brunswick. The streamlined package contains a number of instruments designed to collect data on fluid mud in the Petitcodiac River.

and served to further demonstrate Canada's international leadership in environmental effects research and management. The Canadian delegation, led by Assistant Deputy Minister Dr. Wendy Watson-Wright and comprised of DFO staff and provincial colleagues from across Canada, was well received in Chile. Over a two-week period, the Canadian delegation held bilateral meetings with the Chilean government and universities. The meetings resulted in amendments to Chilean regulatory frameworks and the signing of agreements for further collaboration.

In June and August, Tim Milligan and Brent Law from DFO's Habitat Ecology Section undertook a new project with Gail Kineke and two Masters students from Boston College **to study fluid mud in the Petitcodiac River**, New Brunswick. With funding from the United States Office of Naval Research, the goal of the study was to understand how fluid mud forms and how it affects the movement of water and sediment in areas with large tides and high sediment loads. The Petitcodiac River provides a unique natural laboratory to study the interaction between high concentrations of sediment and flow. A lack of understanding of the effect of fluid mud on sediment deposition is likely the reason that designers severely underestimated the rate and extent of sediment infill downstream of causeways

The Canadian delegation to the Environmental Cooperation for Sustainable Aquaculture workshop in Chile, from left: Renee Plouffe and Sylvain Lefebvre (Canadian Embassy); Carol Ann Rose (DFO,BIO); Wendy Watson-Wright (DFO); Tim Doyle (RCMP); Joey Crocker and Barry Hargrave (DFO,BIO); Robin Anderson and Jon Chamberlain (DFO); Birgit Castledine and Toby Balch (NS Department of Agriculture and Fisheries); Jon Grant (Dalhousie University); Al Castledine (BC Ministry of Agriculture, Food, and Fisheries)

The subtropical snowy grouper

FSRS Fisheries Technician Jen LeBlanc, FSRS Research Biologist Carl MacDonald, and FSRS Inshore Ecosystem Project Officer Nell den Heyer sample catch aboard a fishing vessel during the fishery-independent sampling phase of the Inshore Ecosystem Research Project.

constructed in the upper Bay of Fundy. The inability to characterize the effect of sediment on flow also hampered efforts during the recently completed Environmental Impact Assessment to model the response of the Petitcodiac River to possible changes to the causeway. By defining the parameters that control the formation and resuspension of dense mud layers, we hope to improve our ability to predict the occurrence of fluid mud in this and other environments, and to model its effect on sediment movement. One immediate result from the study was the observation that the 2.5 m-thick fluid mud layer that formed at the end of the flood tide was not resuspended even though the ebb current speed at the surface reached 1 metre per second. Instead, the layer remained coherent and flowed past the Gunningsville bridge, carrying with it warm, fresh water from upsteam. Density stabilization by the very high concentrations of mud near the bottom prevented the water and sediment from being mixed with the overlying water.

The expertise of inshore fishermen contributes to scientific knowledge needed for the **Inshore Ecosytem Research Project**, a joint project between the Fishermen and Scientists Research Society (FSRS) and DFO. To determine the distribution and relative abundance of the whole spectrum of species caught by commercial fishing gear, 42 at-sea samples of the commercial catch were completed in 2005-2006, primarily aboard lobster fishing vessels. In summer 2006, fishermen also assisted in fishery-independent sampling at ten locations off the Atlantic coast of Nova Scotia. As well, fishermen's knowledge of the ecology of the Scotian Shelf is being mapped through a Local Ecological Knowledge Survey.

While diving on the artificial reef in Sambro Harbour in early October, Glyn Sharp, Bob Semple, and Megan Veinot of DFO's Population Ecology Division **discovered four snowy groupers**. Despite its winter name, the snowy grouper is a fish native to North Carolina. Megan was able to capture one of the four and place it in an aquarium for positive identification as a subtropical fish. How this fish smaller than 3 cm long made it 1500 km from its home can be partly explained by the rapidly flowing Gulf Stream that carries water from the Gulf of Mexico toward northern Europe. The eggs float in the surface water and hatch into larvae and are carried at a rate of 50 to 80 km per day northward. To reach the Scotian Shelf they must be carried northward in a meander or tendril of warm water that reaches our shores periodically. The snowy groupers left in Sambro Harbour unfortunately would have perished when the water temperatures dropped in the fall. For several months, the one fish captured was a not-for-sale, star attraction in a local pet shop where it grew to 15 cm before expiring. A full grown snowy grouper can reach a length of 200 cm. A paper on the discovery will appear in the Proceedings of the N.S. Institute of Science.

Education Outreach at the Geological Survey of Canada (Atlantic) in 2006

Jennifer Bates, Sonya Dehler, Gordon Fader, Rob Fensome, David Frobel, Iris Hardy, Nelly Koziel, Bill MacMillan, Bob Miller, Patrick Potter, John Shimeld, Dustin Whalen, Hans Wielens, and Graham Williams

Education outreach remains a force at NRCan's Geological Survey of Canada (GSC). Programs such as the EdGEO workshop series remain popular. The success is mainly due to the collaborative nature of the Atlantic Geoscience Society (AGS) Education Committee of which the GSC Atlantic is a member. Other members include provincial geological surveys, museums, science centres, universities, and schools. In 2006, GSC Atlantic staff also judged at science fairs and gave invited talks at schools, universities, and libraries.

The Nova Scotia EdGEO Workshop Program marked its 13th year in 2006, when the annual August workshop was centred at the Bedford Institute of Oceanography. Two one-day field trips were offered. For the first day's event, Halifax - *The Geologic Landscape of the Halifax Regional Municipality (HRM)*, participants were guided to sites throughout HRM. Day two offered Noel Shore - *Walking Through Time: A Geological Field Trip to the Noel Shore, Minas Basin, Nova Scotia*. This was a cross-country tour from Halifax to the Noel Shore, travelling through geological time from the Cambro-Ordovician to the Quaterary Period.

For 2007, the EdGEO Program will return to the Annapolis Valley; staff of the Department of Geology at Acadia University are planning a two-day field trip.

The success of the Nova Scotia EdGEO Workshop Program depends upon the knowledge, experience, enthusiasm, and dedication of its Committee. Presenters and Committee members represent both the geoscience and education communities: Dottie Alt

A foggy day at famous Peggy's Cove does not prevent Terry Goodwin (NSDNR) from fitting the Devonian granite into Nova Scotia's geological history during an EdGEO field trip.

At Rainy Cove, Hans Wielens (GSC Atlantic) unravels the mystery of this Windsor Group outcrop and its connection to offshore oil and gas.

(Tatamagouche Elementary School); Paul Batson (Nova Scotia Community College [NSCC]: Institute of Technology campus); Andrew Casey, Murray Metherall, and Kathy Silverstein (HRM School Board); Howard Donohoe and Terry Goodwin (Nova Scotia Department of Natural Resources [NSDNR]); Cindy Hiseler and Wendy Spicer (Annapolis Valley School Board); Heather Johnson (Halifax Independent Elementary School); Henrietta Mann and Anne Marie Ryan (Dalhousie University); Nancy Muzzatti and Deborah Skilliter (Nova Scotia Museum of Natural History [NSMNH]); Melanie Oakes (consultant); Bev Williams (NS Association of Science Teachers); and Sonya Dehler, Rob Fensome, Iris Hardy, Nelly Koziel, Bill MacMillan, Patrick Potter, John Shimeld, Hans Wielens, and Graham Williams (GSC Atlantic).

Financial support was provided by the National EdGEO Committee. The GSC Atlantic, NSDNR, NSMNH, Dalhousie University, NSCC, Saint Marys University, various school boards, and Atlantic Science Links Association provided in-kind support.

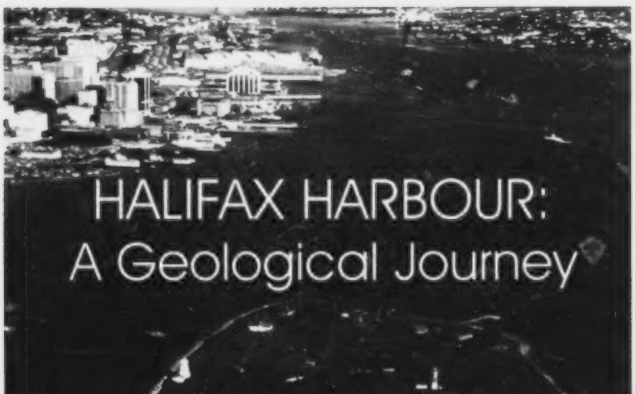
GSC Atlantic staff ran hands-on sessions at the annual conferences of the Association of Science Teachers (AST) and the Social Studies Teachers Association in October 2006. A booth was staffed at the AST conference where the group's activities and products developed under the AGS banner were displayed. These conferences are an excellent way to interact with teachers and understand better how we might bring geology into the classroom and plant the seeds for future generations of scientists and technologists.

The story of the geological history of the Fundy Basin has been transferred to canvas by New Brunswick artist, Judi Pennanen. Five watercolours are complete and in 2007 will be on display at the Fundy Geological Museum. Four of the paintings highlight life and landscapes in the time of the Wolfville, Blomidon, North Mountain, and McCoy Brook formations. The fifth stars a prosauropod. A first draft of an accompanying booklet is in the review stage.

The evening public talk series, *Beyond The Last Billion Years*, continues to attract crowds. The 2006-07 season was moved from the NSMNH to BIO for the five talks.

GSC Atlantic staff are also active members of the AGS Video Committee, which released its most recent production, *Halifax Harbour: A Geological Journey*. This video would interest people who

EdGEO participants


HALIFAX HARBOUR:
A Geological Journey
Produced by Moonglow Digital Video Productions
for the Atlantic Geoscience Society
28 minutes - DVD - English subtitles

AGS-produced DVD

wish to know more about our famous ice-free harbour. Highlights include: a geological history of the harbour; the Mi'kmaq's "Chebucto"; Fortress Halifax and colonial settlement; myths revealed; tales of war and explosions; effects of hurricane Juan; and implications of sea level rise. The video is available for purchase at the BIO Gift Shop or through the AGS website: (http://ags.earth-sciences.dal.ca/ags.php).

Workshops and Special Meetings

2006 was another productive year for the **Regional Advisory Process** (RAP). Twenty-one RAP meetings were held, spanning the full spectrum of ocean advisory issues from the assessment of individual stocks to information needs and sources of entire ecosystems. Three highlight stock assessment-related activities are worthy of particular note. The first was a special meeting to define the indicators to be used in assessing one of the region's largest resources – Southwest Nova Scotia lobster. Well supported by both scientists and industry, the meeting developed an assessment framework for use over the foreseeable future. The second was a comprehensive three-meeting review of all components of the Southwest Nova Scotia herring assessment, initiated to examine the stock boundaries, data inputs (including fishery and survey), and models required for assessment and harvest advice. This review will be completed in 2008. The third highlight was the review of the assessment models used for Georges Bank herring. An earlier review had indicated dramatically different resource outlooks, dependent upon the assumptions used. The RAP meeting developed consensus on the most appropriate assumptions to be used.

Regarding species at risk, recovery potential assessments of North Atlantic shortfin mako and white sharks (of *Jaws* fame) and of loggerhead turtles were undertaken. Although these species live much of their lives elsewhere, they enter Canadian waters in the summer and fall and Canada has an obligation under the *Species at Risk Act* to promote the recovery of these endangered species. A

Inshore Ecosytems and Significant Areas workshop: participants do mapping exercises to identify potential EBSAs based on scientific expert opinion.

special workshop was held to develop a decision support tool that habitat managers can use to determine whether and to what extent endangered Atlantic salmon are present in a stream. Another habitat-related workshop explored the assessment of shoreline habitat and compensation of human impacts. Finally, in response to specific unplanned issues with a short turn-around time, 16 Expert Opinions on an expansive range of issues were requested of Science Branch by fisheries, oceans, and habitat managers. The success of the Expert Opinion process, explored as a pilot in DFO Maritimes Region, was discussed at the national level and has now been adopted across the country.

The **Workshop on Inshore Ecosystems and Significant Areas of the Scotian Shelf** was hosted by DFO Oceans and Habitat and Science branches and the Fishermen and Scientists Research Society (FSRS) at BIO, January 16–19. Participants included government, university, industry, and NGO-supported researchers. Workshop objectives were: (1) to explore our knowledge of the biodiversity, structure, and function of the inshore Scotian Shelf; (2) to explore the criteria and metrics for the identification of ecologically and biologically significant areas (EBSAs); and (3) to identify EBSAs based on scientific expert opinion. Participants identified 36 possible EBSAs in the inshore, and 27 in the offshore. The proceedings are an important first step in the development of the first Ecosystem Overview and Assessment Report for the inshore of the Scotian Shelf and the identification of EBSAs in both the inshore and offshore.

On February 16, DFO's Population Ecology Division organized a workshop to present results to date from **the bottom-mapping project in Scallop Fishing Area 29** (Southwest Nova Scotia). In 2002, a three-year joint project agreement was signed by the scallop fishing fleets, NRCan, and DFO, with all parties providing funds, to conduct multibeam sonar acoustic mapping of the sea floor and associated scientific work. Maps of high-resolution bathymetry, acoustic backscatter strength, and surficial geology have been produced from this project. In addition, benthic data were collected using photographic and video equipment for the analysis of the distribution of benthic assemblages in relation to bottom type. Attending the workshop were 43 researchers, members of the fishing industry, and fisheries managers who were interested in these data and associated analyses.

After a review of the collected data, progress in four areas of research was highlighted. Based upon video and data from the observer program, sea scallops were found in most areas but were most abundant on flat gravel lag and stable sands. Restricting dragging for scallops on the flat gravel lag or in sand could improve catches, minimize gear losses, and greatly reduce bycatch and damage to epibenthic communities, which are the most abundant on bedrock outcrops and till. Bathymetry maps were used in the last three years for planning survey tows and, as a result, gear damage during the annual survey was greatly reduced. The 2005 survey was redesigned using surficial maps, and preliminary results indicate that this new design resulted in more precise estimates of biomass. The commercial catch per unit effort was analyzed using the surficial geology maps and the results suggest that current catch rates are being maintained by moving to previously unfished areas. Discussion after the presentations focused on everything from availability of the data to using these kinds of data to manage fisheries. Overall, the industry representatives were positive about the results but would

have preferred to have more control over their participation. Access to fishing in this area was conditional on the fishermen contributing to funding the project. (Proceedings: DFO, 2006. Presentation and review of the benthic mapping project in Scallop Fishing Area 29, Southwest Nova Scotia. DFO Can. Sci. Advis. Sec. Proceed. Ser. 2006/044.)

On March 10, DFO's Ocean Physics Section hosted an internal **workshop on ocean instrumentation**. The main goals of the workshop were to highlight the capacity for technology development at BIO, to identify anticipated future areas of technology development required to address the needs of programs along the major BIO activity themes, and to determine resource requirements. More than 40 BIO participants from DFO, NRCan, and the Canadian Coast Guard attended. Presentations and discussions revealed the high value of BIO-led technological development, emphasizing how it has been critical to the success of numerous programs and how it has contributed to the local economy through technology transfer. Participants identified areas of technological challenges that will require significant engineering development using available BIO facilities. They also stressed that BIO's future success as leaders in ocean science and the ability to attract key partners hinges on our continued ability to conduct relevant technology development.

On March 27-28, Dr. Michael Parsons of NRCan hosted a two-day **NS Historic Gold Mines Workshop** at BIO to highlight the results of recent multidisciplinary research on the environmental effects of historic gold mining in Nova Scotia. The workshop was organized (1) to communicate key scientific results to the research community and government regulators; (2) to discuss how best to integrate these data into ongoing risk assessments and land management decisions; and (3) to identify gaps in our scientific understanding of the ecosystem and human health risks associated with these sites. Twelve presentations were made by project partners from NRCan, DFO, the Nova Scotia Department of Natural Resources, Queen's University, Environment Canada, and the Royal Military College. The workshop was attended by more than 50 people over two days, including members of the recently formed Nova Scotia Historic Gold Mines Advisory Committee (HGMAC). Following the workshop, Mr. Brent Baxter, Chair of the HGMAC (and Acting Manager of the Pollution Prevention Branch at Nova Scotia Environment and Labour) thanked the project team members, and expressed strong support for continued study of these historical mining sites.

DFO's Ken Frank (Oceans Sciences Division) and Michael Sinclair (Regional Director, Science) co-chaired the annual **meeting of the DFO Fisheries Oceanography Committee**, March 29-31. The major agenda item was the initiation of a comparison of the temporal changes in the structure of ecosystems on the shelf seas of Atlantic Canada, from the Labrador Shelf to the Gulf of Maine area. The focus was on the fish communities, primarily using the observations from the multi-species trawl surveys. The 20 participants from DFO Newfoundland, Quebec, Gulf, and Maritimes (BIO and the St. Andrews Biological Station) regions were experts in ecosystem analysis and modelling, fisheries science, physical and biological oceanography, and database management. The results of the meeting are being used to develop regional ecosystem status reports that will support ecosystem-based fisheries management initiatives. The Fisheries Oceanography Committee has been in existence since 1993 and convenes annual meetings to undertake science issues of zonal significance that require multi-disciplinary approaches for their solution.

The **Bras d'Or Lakes Traditional Ecological Knowledge Workshop** was held at the Sarah Denny Cultural Centre, Eskasoni, Nova Scotia, May 3-4. The purpose was to gather information about the environment of the Bras d'Or Lakes and watershed lands based on traditional ecological knowledge, to support the integrated management process in the Bras d'Or Coastal Management Area. Twenty-five First Nations and twenty-five other community elders were invited to share their knowledge and insights on the ecology of the Bras d'Or. The outcomes of this two-day event will be used in the management planning process. They were published as stand-alone proceedings as well as incorporated into the Bras d'Or Ecosystem Overview and Assessment Report (Canadian Manuscript Report of Fisheries and Aquatic Sciences 2789, 2007).

A working session demonstrating the **Benefits of Partnerships with First Nations** Communities took place during the International First Nations Community Planning Conference in Membertou, Nova Scotia, May 23-25, hosted by the Atlantic Policy Congress of First Nations Chiefs. Co-presentations were made by DFO and the First Nations organizations that are partnering on work in the Bras d'Or Lakes. Presentations were made on the collaborative work in science (Gary Budgen, DFO and Shelley Denny, Unamaki Institute of Natural Resources) and integrated management (Jason Naug, DFO and Shelley Porter, Unama'ki Institute) and highlighted the benefits of working together. Elder Albert Marshall also provided his perspective on these positive working relations.

A **Fisheries By-catch Workshop** was convened June 1 at BIO to review analyses summarizing the observed catch, kept and discarded, from all Canadian fisheries on the Scotian Shelf, Georges Bank, and in the Bay of Fundy, based on at-sea observer recordings. The workshop was in response to action items arising from the Regional Workshop on Implementation of the Oceans Action Plan and was attended by about 30 DFO staff from Science, Fisheries and Aquaculture Management, and Oceans and Habitat branches. Although there was broad consensus that the analyses provided useful insights for characterizing the by-catch and discards, enhanced monitoring is required to address the substantial limitations and gaps in information. Routine accounting of discard mortality will require a consistent, comprehensive, and stable fisheries monitoring program. A follow-up workshop is planned where estimates of total discards, derived by linking the observer information with the fisheries statistical information, will be reviewed.

In 2002, DFO Maritimes Region formed an **Industry Roundtable**, which includes representatives from all aspects of the fishing industry on the Scotian Shelf and in the Gulf of Maine area. The major focus of the roundtable is to address horizontal issues across fishing industry sectors. On June 5, a team from the European Union (EU), whose primary interest was an introduction to Canadian approaches to involve the fishing industry in fisheries management activities, visited BIO. The team was led by Jurgen Holmquist, the Director General of Fisheries for the EU, and was predominantly composed of fishing industry representatives. The Industry Roundtable was opened up to this group. The major agenda item was *The Ecosystem Approach to Fisheries Management*, and the meeting was chaired by Leslie Burke, Regional Director, Fisheries

and Aquaculture.

The **DFO Centre for Ocean Model Development and Application** (COMDA) is a national Virtual Centre of Expertise hosted by BIO. COMDA convened a workshop in October in Montreal for national coordination in the development of an improved atmosphere-ocean-ice prediction capability for Canada. The workshop was attended by representatives from all DFO regions, other federal agencies, and universities. DFO, Environment Canada, and the Department of National Defence plan to work with the Mercator Operational Oceanography Centre in France on the implementation of a version of the latter's global ocean model, coupled with Environment Canada's numerical weather prediction model. This will provide the framework for an improved operational oceanography capability for describing and predicting the state of Canada's oceans and marine ecosystems.

The **Continuous Plankton Recorder (CPR) Workshop** was held at BIO, December 12-13. It was organized by Dr. Erica Head of the DFO Oceans Sciences Division at BIO and Dr. Michael Chadwick of the Gulf Fisheries Centre, Moncton. CPRs provide a cost-effective way of monitoring plankton, the base of the aquatic food chain. Towed by ships of opportunity, they collect plankton samples which are analyzed at the Sir Alister Hardy Foundation for Ocean Science in Plymouth, United Kingdom. DFO is a partner in the operation of routes across the Newfoundland and Scotian shelves and in the Pacific Ocean. At this workshop, the role of the CPR in current monitoring programs and information about CPR data use was discussed, and recommendations were reached for the implementation of new routes as part of future DFO monitoring activities. The twenty-seven attendees came from DFO across the country, NGOs, and Canadian, United States, and French universities.

Seminars

Over the course of the year, BIO welcomed scientists from around the world to present seminars and to lecture at the Institute.

BIO SEMINAR SERIES

The BIO Seminar Series provides an Institute-wide forum for presentations covering topics of physical, chemical, biological, and fisheries oceanography; marine geophysics and geology; hydrography; marine ecology; and ocean engineering. During 2006, the Seminar Series featured the following talks:

How Well are the Fisheries Doing, and What about the Future?
Dr. Michael Sissenwine, Former Director of Scientific Programs, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, Woods Hole, Massacusetts

Seismic Oceanography: A New View of the Oceans
Dr. Steven Holbrook, University of Wyoming, Laramie, Wyoming

Arctic Ocean Drilling Results: Evidence of Extreme Past Climate Change
Dr. Kate Moran, University of Rhode Island, Narragansett Bay, Rhode Island

Several groups within BIO sponsor **speaker series**. These provide forums for sharing BIO science among colleagues, and often feature outside specialists speaking on ocean-related topics.
(The following lists do not include talks given at BIO by in-house DFO and NRCan scientists.)

CENTRE FOR MARINE BIODIVERSITY SEMINARS

The Centre for Marine Biodiversity invites scientists whose research in fisheries, marine ecology, physical oceanography, and related sciences will enhance our knowledge of marine biodiversity.

Can We Measure the Success of Marine Conservation? Degradation and Recovery of Coral Reefs across an Extreme Gradient of Human Disturbance
Dr. Enric Sala, Associate Professor, Scripps Institution of Oceanography, University of California at San Diego, California

Can Species Composition and Species Distribution of Marine Benthic Fauna be used as Proxies for Large-scale Environmental Change?
Dr. Torleiv Brattegard, Associate Professor, Department of Biology, University of Bergen, Norway

GSC MUD CLUB

Mud Club provides an informal opportunity to present findings in marine geoscience by showcasing GSC and DFO research. The following were speakers from outside of BIO to Mud Club in 2006:

Investigation of the Impact of Headland Asymmetry on Associated Sand Banks using Multi-sensor Techniques
Garret Duffy, University of New Brunswick, Fredericton, New Brunswick

Stratigraphic and Paleoenvironmental Studies in Raised Sea Caves, British Columbia: Implications for the Human Coastal Migration Hypothesis
Brent Ward, Department of Earth Sciences, Dalhousie University, Halifax, Nova Scotia

Can Classic Hydrocarbon System Models be Applied to Volcanic Basins? A Numerical Modelling Experiment, Sverdrup Basin, Canadian Arctic Archipelago
Samantha Jones, BSc Honours Student, Dalhousie University

The Most Recent Cataclysmic Flood Event from Ice-dammed Lakes in the Russian Altas Mountains, Siberia: Field Evidences and Age Constraints from Cosmogenic In-situ ^{10}Be
Anne Reuther, Department of Earth Sciences, Dalhousie University

Environmental Change in High Arctic Canada Following the Last Glaciation: Coupling Marine and Terrestrial Records using Dinoflagellate Cysts
Anna J. Piefkowski-Furze, Department of Earth and Atmospheric Sciences, University of Alberta, Edmonton, Alberta

A Low-tech Hard Look at the Abenaki Carbonate Edge: What the Rocks Themselves Tell us about the Setting of Shelf-margin Reefs and the Panuke Gas Field
Leslie S. Eliuk, Geotours Consulting Inc., Lunenburg, Nova Scotia

The Depositional Lobes of the Amazon Fan
Isabelle Jegou, French Research Institute of the Exploitation of the Sea, Issy-les-Moulineaux Cedex, France

HARVEST FISHERIES SEMINAR SERIES

The Harvest Fisheries Seminar Series began in 2002. Hosted by the Population Ecology Division, the primary purpose is to provide an opportunity to exchange ideas and to hear about research both within BIO and at other institutions. Staff who will be speaking outside BIO are encouraged to also give their presentations at the Institute. As well, the program features visiting researchers and speakers from local universities.

Non-market Values of Canadian Aquatic Species at Risk: Preliminary Results from a National Internet Survey
Dr. Murray Rudd, Canada Research Chair, Sir Wilfred Grenfell College, Corner Brook, Newfoundland and Labrador

Decision-making is just as Blind as Evolution: The Logic behind the Mismanagement of our Fisheries
Chris Corkett, Department of Biology, Dalhousie University

Santiago Cuba Bay Issues and Challenges
Leticia Delgado Cobas, Oriente University, Santiago de Cuba, Cuba

Involving Fishers in Fisheries Management: The New European Regional Advisory Councils
Dr. Tony Hawkins, Chair, North Sea Commission Fisheries Partnership, Aberdeenshire, Scotland

Growth, Selective Survival, and Recruitment Variability in Baltic Sprat, Sprattus sprattus
Hannes Baumann, Institute of Hydrobiology and Fishery Science, Hamburg, Germany

Synoptic Ecological Tools for Marine Science in a Pixelated World
Bruce Hatcher, University Chair in Marine Ecosystem Research, Cape Breton University, Sydney, Nova Scotia

Diversifying Issues: Pending Areas of Activity for the DFO Review and Advisory Processes
Jake Rice, Director, Canadian Science Advisory Secretariat, DFO, Ottawa

Do Wandering Albatrosses Really Perform Levy Flights when Foraging?
Andrew Edwards, Biosphere Complexity Analyst, British Antarctic Survey, Cambridge, United Kingdom

The Assessment of Species-at-risk in Canada amidst Growing Pains with SARA
Jeffrey Hutchings, Professor, Department of Biology, Dalhousie University and Chair, Committee on the Status of Endangered Wildlife in Canada

Potential of Advanced, Airborne, Optical Remote Sensing and GIS for Monitoring and Management of Eastern Canada's Shallow Coastal Ecosystems and Resources: Where do We Sit?
Patrick Gagnon, Research Associate, Department of Biology, Dalhousie University

Community-wide Consequences of Declines in Large Predatory Fishes
Travis Shepherd, Postdoctoral Fellow, Department of Biology, Dalhousie University

Dealing with Complex Ecological Data Using Bayesian State-Space Models
Ian Jonsen, Postdoctoral Fellow, Department of Biology, Dalhousie University

Continued Decline of an Atlantic Cod Population: Increasing Trends in Natural Mortality and the Role of Seal Predation
Kurtis Trzinski, Postdoctoral Fellow, Parks Canada

Understanding the Complex Responses of Fish Populations to Harvest
Erin Dunlop, Postdoctoral Research Scholar, Institute of Marine Research, Bergen, Norway

Life in the Arctic – Living and Working in Inuvik, Northwest Territories
Amy Thompson, Environmental Biologist, Gwich'in Renewable Resource Board, Inuvik, Northwest Territories

OCEAN AND ECOSYSTEM SCIENCE SEMINAR SERIES

The Ocean and Ecosystem Science Seminar Series talks are given weekly and cover topics in physical, chemical, and biological oceanography. The series, run jointly by the Ocean Sciences and Ecosystem Research divisions, provided a forum for both local researchers and visiting scientists in 2006:

Interpreting Eddy Fluxes
Richard Greatbatch, Dalhousie University

Adding Oxygen Measurements to Argo - a Pilot Study
Denis Gilbert, Maurice Lamontagne Institute, DFO, Mont-Joli, Quebec

Wave Modelling - Towards the Next Generation - The Nonlinearity Problem
Adhi Susilo, Dalhousie University and **Will Perrie**, DFO Ocean Sciences Division, BIO

An Overview of Ice-Ocean Modelling in the Laurentian Region, and First Validations of the MC2 Kernel for Future Oceanic Simulations
François Roy, Maurice Lamontagne Institute

Development of an Ocean Circulation Model for the Marine Environmental Prediction System in Lunenburg Bay of Nova Scotia
Jinyu Sheng, Dalhousie University

The Search for Ocean Influences on Midlatitude Cyclones
Rick Danielson, Dalhousie University

Spectral Nudging of Coastal Models and Implications for Prediction
Keith Thompson, Dalhousie University

Loss of Salt Marshes and Shoreline Erosion in the Southern Gulf of St. Lawrence: Variation in Time Scales from Days to Centuries
David J. Garbary, St. Francis Xavier University, Antigonish, Nova Scotia

Climate Impacts on North Atlantic Ecosystems: The Relevance of Plankton Monitoring to NAFO
Chris Reid, The Sir Alister Hardy Foundation for Ocean Science, Plymouth, United Kingdom

The Importance of Scale: Understanding Copepod Population Variability in the Western North Atlantic
Catherine L. Johnson, Earth and Ocean Sciences, University of British Columbia, Vancouver, British Columbia

A One-dimensional Ocean-mixing Model of the Strait of Georgia - Ecological Responses to Physical Forcing
K. Collins, Earth and Ocean Sciences, University of British Columbia

Chinese National Program on Bi-Polar Oceans
Zhaoqian Dong, Polar Research Institute of China, Shanghai, China

Towards a Linked Biogeochemical and Fish-Production Model
Wolfgang Fennel, Institut fur Ostseeforschung Warnemuende, (Baltic Sea Research Institute) University of Rostock, Germany

Winds of Change: Evolution of the El Niño Southern Oscillation from the Last Ice Age to Today
Andrew Bush, University of Alberta

The Barcode of Life
Paul Hebert, University of Guelph, Guelph, Ontario

Impact of Labrador Sea Deep Convection on the North Atlantic Meridional Overturning Circulation
Bob Pickart, Woods Hole Oceanographic Institution, Woods Hole, Massachusetts

Coastal Recovery after the 2004 Tsunami and Other Environmental Impact Projects in Southern Thailand
Penjai Sompongchaiyakul and **Yupadee Chaisuksant**, Prince of Songkla University, Songkla, Thailand

Zonal Eddy Heat Transport in the Southeast Pacific
Keir Colbo, Department of Oceanography, Dalhousie University

Adaptive Plankton-DOM Modelling in the North Atlantic
Markus Pahlow, Department of Oceanography, Dalhousie University

Ocean Forecasts for Canadians: Improving Safety at Sea through Prediction of Ocean Behaviour
Fraser Davidson, North Atlantic Fisheries Centre, DFO, St. John's, Newfoundland and Labrador, and Dan Wright DFO, BIO (Canadian Meteorological and Oceanographic Society tour talk)

A Three-dimensional Baroclinic Circulation Model for the Bras d'Or Lakes of Nova Scotia
Jinyu Sheng and **Bo Yang**, Dalhousie University

Celebrations and Special Events

The United Nations, in General Assembly Resolution A/60/30 of November 29, 2005, "welcomes the adoption by the International Hydrographic Organization of **World Hydrography Day**, to be celebrated annually on June 21, with the aim of giving suitable publicity to its work at all levels and of increasing the coverage of hydrographic information on a global basis, and urges all States to work with that organization to promote safe navigation, especially in the areas of international navigation, ports and where there are vulnerable or protected marine areas."

The Canadian Hydrographic Service at BIO celebrated the 1st annual World Hydrography Day on June 21. BIO staff were invited to the auditorium for two presentations. Charlie O'Reilly presented *Atlantic Storm Surge and Tsunami Warning Systems*. The second talk was *Developing a Real Time Water-Level System for Atlantic Canada* by Philip MacAulay. A small reception with a celebratory cake followed.

A **diversity event**, hosted by DFO's Regional Diversity Advisory Council, was held at BIO on November 8. Eighty people experienced a program of guest speakers and cultural entertainment during the morning event. Laughie Rutt, Executive Director of the Canadian Paraplegic Association, in describing his challenges, impressed upon the audience that they should see the abilities people bring to the workplace, rather than any disability. Jules Oliver, President of Zone Switch, through descriptions of his public service and worldwide work with external organizations, encouraged listeners to promote and celebrate differences.

The Filipino Association of Nova Scotia performed two dances. One was the graceful Dance of Light, traditionally performed at the

The Marine Ecology Laboratory Reunion

end of a long day in a Philippine village; the other was the Tinikling Dance, a national folk dance performed to fast music between bamboo poles. Later, the Bell Park Academic Centre Dance Group (comprising 20 girls between Grades 4 and 6) performed two dance numbers to pop and R&B music. During program breaks, guests toured exhibits demonstrating cultural and workplace diversity. Through the enjoyable program and mingling, participants experienced the pleasure and value of diversity.

The **Marine Ecology Laboratory (MEL)** was a world-class ecological research laboratory located at BIO. It grew out of the Atlantic Oceanographic Group under the Fisheries Research Board of Canada and attained laboratory status in 1965. For 22 years it conducted leading-edge research on biological, fisheries, and environmental oceanography, and contaminants. MEL was disbanded in 1987 by DFO as part of government reorganization but most staff continued to carry out ecological research under the new science organization. On Friday, November 17, a **reunion** was held in the BIO auditorium. More than 50 former staff attended, along with a large number of other past and present members of the BIO scientific community. The day-long program included presentations on the history and philosophy behind the formation of MEL, an illustrated history of MEL, the impact of MEL research on the conduct and understanding of ecological science today, and the dissolution of MEL and implications for ecological research at BIO. In addition, many stories of past events were shared. The reunion concluded with a gala dinner at the Westin Hotel in Halifax.

Visitors

On October 26, BIO hosted a group of fishermen, scientists, and fisheries managers from Ireland. They represented the **Northern Ireland Fish Producers Organisation** and their trip was sponsored by the European Union. The topics discussed were: oceanography and climate change with Ken Frank; scientists and fishermen interactions with the Fishermen and Scientists Research Society, Ross Claytor, and Peter Hurley; stock assessments with Sherrylynn Rowe; by-catch with Mark Showell; and seals with Bob Mohn. As well, the visitors were given a tour of the CCGS *Hudson*. The issues the visitors raised were similar to those we face here among scientists, fishermen, and fisheries managers, and it was interesting to hear their views on the same issues we face in our stock assessments.

Peter Stoffer, M.P., the NDP member for Sackville and the Eastern Shore, visited BIO on November 16. Presentations were given on mapping activities of the Department of National Defence,

A Kenyan delegation visits BIO: from left, Dr. Sam Ng'ang'a Macharia, Justus Kianga, Hon. Peter Njeru Ndwiga, Tim Hall, Her Excellency Prof. Judith Bahemuka - photo courtesy of Michael Oloo.

the Canadian Hydrographic Survey, and NRCan, as well as on the Oceans Action Plan activities in the Eastern Scotian Shelf and Bras d'Or Lakes management areas. The presentations were followed by a short tour of the fish lab, with a focus on the shark and seal programs. The visit ended with a discussion of the role of BIO in the transfer of technology to the private sector through commercialization efforts.

On November 16, a **Kenyan delegation** led by Kenya's Minister of Cooperative Development and Marketing, Hon. Peter Njeru Ndwiga, and the Kenya High Commissioner to Canada, Her Excellency Prof. Judith Bahemuka, toured BIO. The visit was organized by Dr. Sam Ng'ang'a Macharia, a research fellow with Oceans and Habitat (O&H) Branch of DFO at BIO. The delegation also included the First Secretary and Economic Affairs Officer at the High Commission in Ottawa, Mr. Michael Oloo, and the Personal Assistant to the Minister, Mr. Justus Kiago. Tim Hall, Assistant Regional Director of O&H, hosted the delegation. The visit began with a tour of the Gully Room and the Sea Pavilion, after which the delegation joined Mark Cusack, Aquaculture Development Director, for a presentation and discussion on how Kenyan local communities can benefit from BIO expertise involving subsistence and commercial aquaculture operations.

The Luna moth at BIO

In June, BIO staff were treated to a rare visit from a **Luna moth**. Lunas are more common in the eastern United States, but can also reach Nova Scotia. Sightings are uncommon because they fly by night and the adult moth has a life span of only one week. With a wingspan of about 11.5 cm (4.5 in), these beautiful, green moths are among the largest in North America.

PEOPLE AT BIO

Awards and Honours

Carl Myers, DFO Communications Manager at BIO, was awarded the national **Leadership and Excellence in Communications Award**, given yearly to a federal government communicator who has demonstrated a high degree of professionalism and contributed to enhancing the profile and standards of communication within the federal government. Over 27 years with DFO, Carl's expertise has contributed to the success of a variety of projects including the Scotia-Fundy Communications Secretariat, the Fishermen and Scientists Research Society, The Gully Marine Protected Area, and, more recently, his work for the Centre for Offshore Oil and Gas Environmental Research (COOGER), as well as initiatives with other organizations.

Dr. Graham Williams of NRCan was awarded the **J. Willis Ambrose Medal** by the Geological Association of Canada (GAC). Named after the first GAC president, the annual award recognizes sustained dedicated service to the earth science community in Canada. Graham was recognized "for his paleontological and stratigraphic research, for his fundamental role as an innovator in geoscience in Canada, and for his tireless mentorship to generations of young geoscientists."

Carl Myers receives the Leadership and Excellence in Communications Award from General Rick Hillier, Chief of Defence Staff of the Canadian Forces.

Captain Joe Bray was awarded the **BIO-Oceans Association Beluga Award** for his dedication and professionalism over many years in support of BIO's research programs. The long-time captain of the MV *Navicula*, and now skipper of the fisheries patrol vessel CCGS *Pont Caveau*, was described as being "competent, co-operative, considerate, and friendly". The international reputation of BIO is owed in no small way to Joe Bray and his colleagues.

Dalhousie University awarded NRCan's Emeritus Scientist, **Dr. Alan Grant**, an **Honorary Doctor of Laws** degree at the convocation ceremony for the Faculty of Science on May 29, in recognition of his contributions to understanding of sedimentary geology in Canada.

The display area outside the cafeteria provides a showcase for the work of BIO scientists. Displays are changed monthly, and at year's end a committee representing the participating groups judges the presentations on visual impact, communication value, science promotion value, and other factors. The winning team receives a small trophy, and both first- and second-place finishers receive gift certificates to a local restaurant. For 2006, the **BIO Display Awards** went to:

1st ***Toward a Bras d'Or Coastal Management Area***
Stan Johnston, **Dave Duggan**, and **Jennifer Hackett**
Oceans and Coastal Management Division, DFO

2nd ***Conserving the Forests and Reefs of Offshore Nova Scotia, Canada***
Derek Fenton, **Heather Breeze**, and **Paul Macnab**
Oceans and Coastal Management Division

Honourable Mention: ***Groundtruthing Seismic Displacement***
David Mosher and **Borden Chapman** (Geological Survey of Canada [Atlantic], NRCan); **Kathryn Moran** (Graduate School of Oceanography, University of Rhode Island); **David Tappin** (British Geological Survey, Nottingham, UK); **Timothy Henstock** and **Lisa McNeill** (National Oceanography Centre, Southampton, UK), and **SEATOS Shipboard Scientific Party.**

The **Unama'ki-Fisheries and Oceans Scholarship** was again awarded to Dalhousie University Professor **Anna Metaxas** and

BIO Display Award presentation: from left, front: Carol-Ann Rose (Acting Director, Oceans and Habitat Branch) and Dave Duggan; back: Jennifer Hackett, Penny Doherty, Stan Johnston, Jason Naug, and Denise McCullough.

doctoral student **Erin Breen**, to continue their project *Patterns in Colonization of the Alien Green Crabs in the Bras d'Or Lakes and Consequences for Native Decapods*. This scholarship is awarded jointly by DFO and the Unama'ki Institute of Natural Resources for a graduate research project related to the natural resources of Cape Breton Island, in particular the Bras d'Or Lakes. The researchers undertake to mentor and include in their research activities a high school student from one of the Cape Breton First Nations.

NRCAN AWARDS 2006

Natural Resources Canada Sector Merit Awards honour staff for their support of NRCan's vision, mission, goals, and objectives; enhancement of the organization's profile; and contributions to its success. The following staff of the Geological Survey of Canada (Atlantic) received Earth Sciences Sector Merit Awards.

Maureen MacDonald provides exceptional administrative support to the Geoscience for Oceans Management Program. She has been central to program successes, by coordinating activities between regions and projects, providing support to the Program Manager and staff from across the country, assuming responsibility for developing and administering research agreements, and assisting with budgeting and international travel planning.

Edward King, **Bob Courtney**, **Patrick Potter**, and **Sheila Hynes** found and re-interpreted data from the archives to assist in the search operation following an accident involving a Canadian military helicopter on the night of July 13. The team's enthusiastic response and rapid communication regarding seabed conditions at the site provided essential information for the search operation.

NRCan Merit Award winner, Maureen MacDonald, with the Assistant Deputy Minister (ADM) of Earth Sciences, Mark Corey

Phil O'Regan overcame numerous obstacles to ensure that marine maps produced by the Geoscience for Oceans Management Program are of the highest quality. His attention to detail and dedication are very much appreciated. Moreover, Phil was Second Place Map Gallery winner at the Atlantic ESRI conference for his submission of *Surficial Geology, Halifax Harbour*, and his map was also selected, out of more than 50 entries, for the ESRI 2006 calendar.

Ruth Jackson and **Gordon Oakey**, as part of a team of project leaders for the Northern Resources Development Program, embraced new challenges and undertook their new roles with dedication. This

NRCan Merit Award winner, Edward King, with ADM Mark Corey

NRCan Merit Award winner, Phil O'Regan, with ADM Mark Corey

NRCan Merit Award-winning Northern Resources Development Program team, including, from BIO: Ruth Jackson, front, far right; Gordon Oakey, Row 2, 2nd from right

group designed a suite of projects to form a coherent program that addressed the issue of responsible development of mineral and energy resources for northern communities and was part of the leading edge in charting the course for the successful implementation of the NRCan Science and Technology Strategy.

DFO AWARDS, 2006

The DFO **Distinction Award** is granted to an employee for outstanding achievement and contributions that further the objectives of DFO and/or the Public Service of Canada. The award is based on excellence in service delivery; valuing and supporting people; and value, ethics, and excellence in policy and/or science. The most exemplary contributions to DFO are honoured with the **Deputy Minister's (DM's) Prix d'Excellence** or the **ADM's Award**.

DM's Prix d'Excellence:

Kelly Bentham (Science Branch) assembles complex electromechanical and electronic components into imaging systems used for visualizing the ocean bottom. He also operates the remote-controlled cameras in collaboration with ship scientists. Post-cruise, he brings creativity to the production of all types of visual products, which are the key to the success of many science programs and help make DFO's scientific research accessible and interesting to a wider audience.

Kenneth Lee (Science Branch) is the Executive Director of

DFO DM's Prix d'Excellence Award winners, include, from BIO: front: Cynthia Webster, 2nd from left, Ken Lee, far right; back: Kelly Bentham, 2nd from left. Photo also shows: back: Coast Guard Commissioner George Da Pont, far left and Deputy Minister Larry Murray, far right; and front: Faith Scattolon, Maritimes Regional Director-General.

COOGER, where his collaborative approach to research and funding at national and international levels has resulted in a state-of-the-art chemistry laboratory complex at BIO and a wave-tank facility for the development and validation of oil spill clean-up technologies. Under his leadership, COOGER has set out the research agenda required before lifting the moratorium on oil and gas activities off the Pacific coast, advocated habitat monitoring programs, and helped develop regulations for the oil and gas industry and international guidelines for oil-spill response technologies. Dr. Lee's expertise and integrity make him an excellent spokesman in support of DFO's mandate of protecting the marine environment.

Beyond her regular duties as senior aquaculture advisor, **Cynthia Webster** (Oceans and Habitat [O&H]) in 2005 led an intergovernmental working group to harmonize the regulatory regimes of three governments involved in industry oversight, a task that required exceptional diplomacy and persistence. At the same time, she enthusiastically performed the secretariat duties for the region-wide Task Force on Fostering a Sustainable Salmon Farming Industry for Atlantic Canada, and, for the third year in a row, helped organize a regional administrative support staff/middle managers forum to promote mentoring, learning, and workplace improvement.

ADM's Distinction Awards, Oceans and Habitat:

A key component of the Environmental Process Modernization Plan is to streamline regulatory reviews of low risk referrals and to develop management tools based on the Risk Management Framework; the Operational Statements are one of the first tools put in place to streamline low risk referrals. **Brian Jollymore** and **Paul Boudreau** were members of the team that worked diligently to develop and implement the first 13 Operational Statements. In persevering despite considerable challenges and conflicting views, they demonstrated leadership and support of DFO's vision of achieving more efficient, transparent, and modern practices.

Derek Fenton and **Heidi Schaefer** were members of the Oceans and Habitat Management *Species at Risk Act* (SARA) Working Group that has made significant progress in evaluating proposed SARA policies and in clarifying SARA requirements to regional staff. In so doing, they have not only developed quality policies and guidance but also have demonstrated excellence in building linkages

between National Headquarters and regions. The group is an excellent example of how leading-edge work has been accomplished through co-operation and collaboration.

ADM's Distinction Awards, Science:

Judy Hammond, Richard Palmer, and **Doug Regular** of the Canadian Hydrographic Service (CHS) were the Maritimes members of the national CHS BSB Raster Chart Project dedicated to the enormous task of preparing a new product line—from developing new software to training a new team—and ultimately creating 650 raster electronic charts, packaging, and setting up a distribution process. Richard Palmer laid the groundwork for this and other projects by developing the framework and managing the On Datum Chart Project. Judy Hammond reviewed the navigational Aids Data Base and verified the Atlantic chart products, which resulted in numerous enhancements to ensure they were usable for modern electronic navigation. Doug Regular has worked extensively on raster charts and on this project made significant contributions to its start-up, production, and quality control.

DFO Distinction Awards:

Paul Thom and **Juanita Pooley** (Informatics) were part of a national team that designed and implemented the Windows 2003 Active Directory structure for DFO's Information Technology infrastructure. They were key participants in the planning and execution of the project, which migrated the department's computing infrastructure to the Windows 2003 environment, and contributed significantly to the development of initial change management processes within Information Management and Technology Services.

Phil Zamora (O&H) has been instrumental in building a credible and professional DFO presence for the Fish Habitat Management Program in Maritimes Region. He has successfully led new and controversial files, in a manner that helped establish excellent and cooperative working relationships. A mentor and leader, Phil also has played a key role in building and developing a strong DFO Habitat Management team.

Cynthia Webster (see DM's Prix d'Excellence)

Catherine Schipilow brings to the CHS competence, a can-do attitude, exemplary leadership, a commitment to quality service and products, and care of the people of the CHS. A pioneer in digital mapping, she embraced quality management with its principles of continuous improvement, and contributes greatly to the well being of the CHS as a member of the Atlantic Region management team and the national HR committee, and as a mentor and volunteer.

Kenneth Lee (see DM's Prix d'Excellence)

The **Population Ecology Division (PED) team of: Alida Bundy, Manon Cassista, Ross Claytor, A. Jamie Gibson, Danielle MacDonald, Rachelle Noel, Shane O'Neil, Stacey Paul, David Robichaud, James Simon,** and **Stephen Smith**, devised and implemented an innovative approach to incorporate employee input in the design of the new division formed by the merger of the Marine, Invertebrate, and Diadromous Fish divisions. After an all-staff event in early February to examine options for organizing the PED, they evaluated the results and, by mid-March, had developed an implementation plan for an operational structure that reflects staff's desire for a project-based team approach and work flexibility. The team provided leadership, seized opportunities for effective change, fostered creativity of employees at all levels, and implemented a customized solution to improve workplace well-being issues.

The BIO Oceans Association: Highlights of 2006

Betty Sutherland, President

The Bedford Institute of Oceanography Oceans Association (BIO-OA) was established in 1998 by a group of former BIO staff to foster the continuing fellowship of members and maintain links to the Institute. At present, there are 191 members representing a broad spectrum of the scientific, hydrographic, technical, and administrative disciplines at BIO. Membership is not restricted to former employees but is open to all who share the association's objectives: preserving oceanographic archival material, particularly relating to research carried out at BIO; increasing awareness and understanding of the oceans and ocean science; and providing opportunities for members to maintain relationships formed at BIO. The BIO-OA's quarterly newsletter keeps members informed of its activities and those of its members. For more information, visit the website at (www.bedfordbasin.ca).

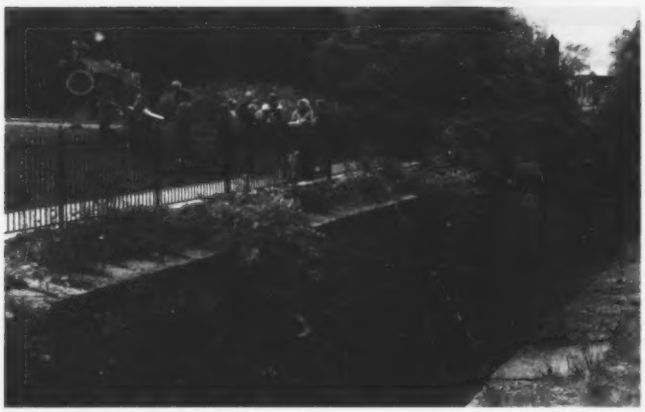
LIBRARY, EQUIPMENT, AND PHOTO ARCHIVES

Work continued through 2006 on preserving oceanographic archival material. The objective of the Library Archives is to preserve all BIO records with research value that are not acquired by the National Archives of Canada, including cruise reports and contributions to national and international organizations. The Photo Archives has undertaken the task of identifying and cataloguing pre-1980 photographs. The Equipment Archives preserves oceanographic equipment developed at BIO, and the knowledge around it. This year the Equipment Archives Committee began the tasks of identifying technology-related posters which should be included in the Library Archives and finding appropriate storage space for the archived equipment.

OCEANS OUTREACH INITIATIVE

Much of the OA executive's attention in 2006 focused on the development of a new project, the Oceans Outreach Initiative (OOI), which features two key elements: a suite of 6 to 12 new dynamic displays intended to augment and modernize the present BIO public education display infrastructure, and new outreach activities aimed at engaging the general public, tourists, and career-minded young science students regarding the work and mission of the BIO departments. The outreach activities would expand the existing summer program into a

Bosko Loncarevic, Clive Mason, and Bob Cook at the BIO-OA Summer Barbeque



OA tour of the Shubenacadie Canal locks

year-long one by incorporating a wider mix of educational offerings (e.g., summer science camps, speaker's bureau programs, workshops for students and the public on critical ocean issues, etc.).

The proposed initiative is anticipated to emphasize lifelong learning and provide career direction to science-minded students, thus helping secure a future pool of human resources needed to be stewards of Canada's ocean and geomarine assets under evolving globalization models; add more oceans and geo-resources content to Halifax Regional Municipality ancillary public education; highlight important BIO departmental research, ocean engineering, monitoring, and regulatory themes that are critical to effective long-term resource management and conservation; and integrate into displays government marine research, operational hardware developments, and resource management strategies in ways that speak to Canada's ocean and marine sciences heritage. It is intended that key elements of the proposal will be developed and funded over a five-year time frame (2007-2011).

The general membership approved the project at its Annual General Meeting on May 4. Following discussions, BIO management and the DFO Regional Director-General gave approval in principle to the ongoing development and implementation of this project, subject to the availability of space required for the displays and the BIO-OA being successful in raising the funds ($2+ million) required for its implementation. Work on this proposal will continue through the coming year.

BELUGA AWARD

At the Annual General Meeting, Captain Joe Bray, long-time captain of the MV *Navicula* before she was retired and now skipper of the fisheries patrol vessel CCGS *Point Caveau*, was awarded the BIO Oceans Association annual Beluga Award in recognition of his dedication and professionalism over the years in support of BIO's research programs.

MEMBERSHIP ACTIVITIES

During 2006, the OA held five social events. On February 12, our Winter Celebration featured an illustrated talk by Zoe Lucas, *Sable Island: Natural History, Stewardship and Research*. On a very rainy August 15, the Summer Barbeque was held at the home of Bob and Heather Cook. Fortunately, participants were able to stay dry and comfortable inside their home. For those interested in local history, Carol and Keith Manchester organized a tour of the Shubenacadie Canal locks on October 25. On November 23, local historian, Janet Kitz, gave an illustrated talk on the Halifax Explosion to an audience of more than 50 people. As usual, members joined BIO staff and their families for the Christmas party on December 22. In keeping with its objective to provide opportunities for social contact among members, the OA's executive undertook a formal Social Activities Poll of its membership. The results will be used in planning future events.

Charitable Activities at BIO

Bettyann Power (DFO), Maureen MacDonald (NRCan), Sheila Shellnut (DFO), and Darrell Harris (DFO)

The Government of Canada Workplace Charitable Campaign (GCWCC) is the oldest and largest workplace charitable campaign in Canada. In 2006, approximately 50 local agencies benefited from this campaign which brings together two main recipient organizations—United Way and Healthpartners—in a co-ordinated fundraising effort. Employees are also encouraged to give to a third option of the campaign, their Charity of Choice(s). In 2006, DFO employees at BIO donated $65,629. This amount does not include the DFO BIO retiree donations since these are tracked nationally. NRCan's campaign was successful with a contribution to the GCWCC of $16,610.82 raised through payroll deductions and special events.

Special events were held to start the campaign and also to add energy and money throughout the program. These included a BIO kick-off where employees brought in new and used sports gear for the local Boys and Girls clubs; a Leadership Thank You Breakfast (sponsored by the Federal Council) at the CFB Officers' Mess; a used book sale coordinated by the library staff; a carved pumpkin auction; NRCan's annual pumpkin carving/cooking competition on

The Uhuru Peak of Mount Kilimanjaro

Darrell Harris at the summit of the Uhuru Peak

Hallowe'en, when many tasted pumpkin fudge for the first time; and the BIO Christmas party that included a hockey game, family skate, light supper, and adult dance. Special guest hockey player was former DFO Minister Geoff Regan, who suited up to play for the "Nights in White Satin" team. Although his team lost, he scored the last goal for his team.

Staff annually support the Community Care Network/Parker St. Food and Furniture Bank at Christmas, when BIO employees donate their time to pack and deliver food boxes to needy families. NRCan contributed special event funds to pay for the four vans used to deliver the Christmas meals. The food bank was supported also through an Institute-wide food and winter clothing drive.

In a special fundraising activity for Feed Nova Scotia, staff contributed to the participation of their colleague, Darrell Harris, in the Hunger Hike, where each of six climbers committed to raising $10,000 in support of the 155-member food banks in Feed Nova Scotia. Individual donations, a Superbowl party, chili party, and BIO Silent Auction raised money associated with Darrell's climb of the Uhuru Peak of Mount Kilimanjaro. Although the trek up was fraught with the perils of extreme mountain climbing, Darrell and his fellow hikers reached the summit on March 3 at 3:33 pm during difficult weather conditions of snow, hail, strong winds, and very, very cold temperatures, not to mention the 50% reduction in oxygen at 19,339 feet (5894.5 metres) above sea level. From all sources, Darrell raised $13,761 for Feed Nova Scotia; he covered travel costs himself.

The Ecosystem Research Division maintained its tradition of making Christmas merrier for those less fortunate. Their popular coffee parties at Easter and Hallowe'en are enjoyable social gatherings for the Institute while helping those in need. As well, a staff member

The ERD group wraps Christmas presents for needy families, from left: Victoria Clayton, Darlene Mossman, Jean-Marc Nicolas, Dawn Sephton, and Cynthia Bourbonnais-Boyce.

in the division has a special ability for persuading folks to buy tickets on a theme item for the event, i.e., an Easter basket and a Jack-o-Lantern. The people helped in 2006 included single parents with young children, a family that lost everything in a fire, and a family coping with a disability while struggling with everyday bills. This year, to stretch the budget, staff contributed items for stocking stuffers.

In further charitable activity, BIO Friends of Symphony Nova Scotia continued support of the symphony's Celebrity Concert Series through the Musical Chair of viola musician, Binnie Brennan; the Canadian Cancer Society's annual daffodil sale was well subscribed; the SPCA was supported with funds and supplies; and other charities were helped on an occasional basis.

People at BIO in 2006

DEPARTMENT OF NATIONAL DEFENCE

LCdr Jim Bradford
Lt(N) Eric MacDonald
CPO2 Ghislain Charest
PO1 Drew Tavares
PO2 Christa Ryan
PO2 Emile Roussy
PO2 Jeff Sooley
PO2 Ivan Lightwood
PO2 Jim McNeill
MS Karen Warren
MS Mike Comrie
LS William Brown
LS Yann Beaulieu

ENVIRONMENT CANADA

Christopher Craig
Patti Densmore
David MacArthur
James Young
Margot Boudreau, Student
Alison Dube, Student
Bryan Heard, Student
Robbie MacLeod, Student
Matt Redgrave, Student
Lauren Steeves, Student

FISHERIES AND OCEANS CANADA

Canadian Coast Guard - Technical Services

Marine Electronics
Jim Wilson, Supervisor
Terry Cormier
Gerry Dease
Jason Green
Julie LeClerc
David Levy
Robert MacGregor
Richard Malin
Morley Wright
Mike O'Rourke

Vessel Support
Andrew Muise, Supervisor
Richard LaPierre
Ensor MacNevin
Lawrence Morash (secondment)
Steve Myers
Lloyd Oickle
Harvey Ross
David Usher

Marine and Civil Infrastructure
Martin LaFitte
Leonard Mombourquette
Richard Myers
Raymond Smith

Dartmouth Technical Workshop
Paul McKiel, Supervisor
Lorne Anderson
Barry Baker
Bob Brown
Ray Clements
Chris Currie
Peter Ellis
Milo Ewing
Brian Fleming
Heather Kinrade
Susan Kolesar
Chad Maskine
Doug Murray
Derek Oakley
John Reid
Helmut Samland
Mike Szucs
Phil Veinot

Canadian Coast Guard - Operational Services

Michelle Brackett

Science Branch

Regional Director's Office
Michael Sinclair, Director
Karen Curlett
Bethany Johnson
Sharon Morgan
Sherry Niven
Bettyann Power

Canadian Hydrographic Service (Atlantic)
Richard MacDougall, Director
Bruce Anderson
Carol Beals
Dave Blaney
Frank Burgess
Fred Carmichael
Mike Collins
Chris Coolen
Gerard Costello
Andy Craft
John Cunningham
Elizabeth Crux
Tammy Doyle
Theresa Dugas
Steve Forbes
Jon Griffin
Judy Hammond
James Hanway
Heather Joyce
Glen King
Mike Lamplugh
Christopher LeBlanc
Philip MacAulay
Bruce MacGowan
Carrie MacIsaac
Grant MacLeod
Clare McCarthy
Dave McCarthy
Paul McCarthy
Mark McCracken
Dale Nicholson
Larry Norton
Stephen Nunn
Charlie O'Reilly
Nick Palmer
Richard Palmer
Paul Parks
Stephen Parsons
Bob Pietrzak
Doug Regular
Gary Rockwell

Term and casual employees, interns, students, and contractors are listed if they worked at BIO for at least four months in the year 2006.
* Retired in 2006

Glenn Rodger
Dave Roop
Tom Rowsell
Chris Rozon
Mike Ruxton
Cathy Schipilow
June Senay
Alan Smith
Andrew Smith
Christian Solomon
Nick Stuifbergen
Michel Therrien
Herman Varma
Wendy Woodford
Craig Wright
Craig Zeller

Ecosystem Research Division
Thomas Sephton, Manager
Debbie Anderson
Sheila Shellnutt
Judy Simms
Paul Keizer*

Marine Chemistry Section:
Phil Yeats, Head
Jim Abriel*
Byron Amirault
Carol Anstey
Robert Benjamin
Chiu Chou
Pierre Clement
Kathryn Dunphy, Student
Grazyna Folwarczna
Susan Hannan
Jocelyne Hellou
Jim Leonard*
Stephen Marklevitz, Student
John Moffatt*
Richard Nelson
Lisa Paon
Ashley Parson, Student
Brian Robinson, Student
John Smith
Peter Strain*

Centre for Offshore Oil and Gas Environmental Research (COOGER):
Kenneth Lee, Executive Director
Rosalie Allen Jarvis
Matthew Arsenault
Jay Bugden
Susan Cobanli
Andrew Cogswell
Jennifer Dixon
Peter Fleming
Amanda Hill
Paul Kepkay
Jamie Joudrey
Thomas King
Zhengkai Li, Postdoctoral Fellow
Amanda Parks
Peter Thamer
William Yeung

Habitat Ecology Section:
Timothy Milligan, A/Head
Cynthia Bourbonnais
Peter Cranford
Lorraine Hamilton
Gareth Harding
Barry Hargrave*
Stephanie Howes, Student
Brent Law
Barry MacDonald
Kevin MacIsaac
Paul MacPherson
Meghan McVeigh, Student
Jean Marc Nicolas
Shawn Roach
Dawn Sephton
Koren Spence
Sean Steller
Amy Thompson
Herb Vandermeulen
Bénédikte Vercaemer
Kees Zwanenburg
Jaime Vickers

Biological Oceanography:
Glen Harrison, Head
Jeffrey Anning
Florence Berreville, Student
Bilal Bjeirmi
Benoit Casault
Carla Caverhill
Leslie Harris
Kelly Haussler
Erica Head
Edward Horne
Mary Kennedy
Marilyn Landry
William Li
Alan Longhurst, Visiting Scientist
Heidi Maass
Markus Pahlow, Research Associate
Kevin Pauley
Linda Payzant
Catherine Porter
Douglas Sameoto*
Jeffrey Spry
Alain Vézina
Tim Perry

Centre for Marine Biodiversity:
Ellen Kenchington, Director
Victoria Clayton

POGO Secretariat:
Shubha Sathyendranath, Executive Director
Emmanuel Devred, Research Associate
Marie-Hélène Forget, Student
Cesar Fuentes-Yaco, Research Associate
Tony Payzant
Suzanna Roy, Visiting Scientist

Ocean Sciences Division
Peter Smith, Manager
Gabriela Gruber
Meg Burhoe*

Coastal Ocean Science:
Simon Prinsenberg, Head
Byoung An, Postdoctoral Fellow
Dave Brickman
Gary Bugden
Sandy Burtch
Jason Chaffey
Joël Chassé
Brendan DeTracey
Adam Drozdowski

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Paul Dunphy
Ken Frank
Dave Greenberg
Charles Hannah
Anitha Nair, Student
Ingrid Peterson
Brian Petrie
Liam Petrie
Roger Pettipas
Trevor Platt
Seung-Hyun Son, Postdoctoral Fellow
Charles Tang
Chou Wang
George White
Yongsheng Wu

Ocean Circulation:
John Loder, Head
Robert Anderson
Karen Atkinson
Kumiko Azetsu-Scott
Michael Dunphy, Student
Yuri Geshelin
Sharon Gillam-Locke*
Blair Greenan
Doug Gregory
Martha Guerreiro, Visiting Student
Helen Hayden
Ross Hendry
Jeff Jackson
Peter Jones
David Kellow
Zhenxia Long, Visiting Scientist
Youyu Lu
William Perrie
Tara Rumley
Hui Shen, Visiting Scientist
Marion Smith
Jie Su, Visiting Scientist
Adhi Susilo, Student
Brenda Topliss
Bash Toulany
Zeliang Wang, Visiting Scientist
Dan Wright
Fumin Xu, Visiting Scientist
Zhigang Xu, Visiting Scientist
Yonghong Yao, Visiting Scientist
Igor Yashayaev
Frank Zemlyak*
Lujun Zhang, Visiting Scientist
Weiging Zhang, Visiting Scientist

Ocean Physics:
Michel Mitchell, Head
Jay Barthelotte
Brian Beanlands
Don Belliveau
Kelly Bentham
Rick Boyce
Derek Brittain
Norman Cochrane
John Conrod
Mylene Di Penta
Helen Dussault
Richard Eisner
Bob Ellis
Jim Hamilton
Adam Hartling
Bert Hartling*
Alex Herman*
Bruce Julien
Randy King
Mike LaPierre
Daniel Moffatt
Glen Morton
Neil MacKinnon
Val Pattenden
Todd Peters
Merle Pittman
Nelson Rice
Bob Ryan
Murray Scotney
Greg Siddall
George States
Leo Sutherby

Science Informatics Section
John O'Neill, Head
Lenore Bajona
James Buchanan, Student
Mark Dennis, Student
Anthony Joyce
Kohila Thana
Jeremy Wright, Student

Population Ecology Division
Ross Claytor, Manager
Doug Aitken
Peter Amiro
Shelley Armsworthy
Jerry Black
Shelley Bond
Don Bowen
Rod Bradford
Bob Branton
Dylan Buchanan
Alida Bundy
Steve Campana
Dollie Campbell
Henry Caracristi
Manon Cassista
Amy Chisholm
Jae Choi
Peter Comeau
Adam Cook
Michele Covey
Tania Davignon-Burton
Daniela Denti
Wanda Farrell
Mark Fowler
Cheryl Frail
Jamie Gibson
Carolyn Harvie
Brad Hubley
Peter Hurley
Eric Jefferson
Brin Jones
Warren Joyce
Raouf Kilada
Peter Koeller
Mark Lundy
Bill MacEachern
Jim McMillan
Linda Marks
Larry Marshall
Tara McIntyre
Romney McPhie
Bob Miller
Bob Mohn
Kathy Mombourquette
Rachelle Noel
Steve Nolan
Shane O'Neil
Patrick O'Reilly
Doug Pezzack
Alan Reeves
Craig Reynolds
Jim Reid
Ginette Robert*
Dale Roddick
Sherrylynn Rowe
Karen Rutherford
Bob Semple
Glyn Sharp
Mark Showell
Angelica Silva
Jim Simon
Steve Smith
Debbie Stewart
Nancy Stobo*

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* Retired in 2006

Wayne Stobo
John Tremblay
Megan Veinot
Jennifer Voutier
Cathy Wentzell
Daisy Williams
Scott Wilson
Linda Worth-Bezanson
Gerry Young
Ben Zisserson

Population Ecology Division Offsite Employees:
Mary Allen
Leroy Anderson
Peter Ashfield
Krissy Atwin
Denzil Bernard
Christopher Carr
Corey Clarke
Glori-Ann Cox
Bev Davison
Sean Dolan
Gilbert Donaldson
Jim Fennell
Claude Fitzherbert
Jason Flanagan
David Francis
Trevor Goff
Michael Goguen
Randy Guitar
Ross Jones
Craig Keddy
Beth Lenentine
Judy Little
Bill MacDonald
Danielle MacDonald
John Mallery
Christian Nadeau
Kevin Nauss
Andrew Paul
Robert Pelkey
Greg Perley
Rod Price
Francis Solomon
Louise Solomon
Brian Sweeney
Michael Thorburne
Malcolm Webb
John Whitelaw
Gary Whitlock
Ricky Whynot
William Whynot
Emilia Williams

Gulf Fisheries Centre – Diadromous Fish Section
Paul LeBlanc

Centre for Science Advice, Maritimes Region and Gulf Region
Bob O'Boyle, Coordinator
Kathryn Cook, Student
Steven Fancy, Student
Joni Henderson
Valerie Myra
Sarah Shiels, Student
Tana Worcester

Oceans and Habitat Branch

Regional Director's Office
Carol Ann Rose, A/Regional Director
Trudy Wilson, Assistant Regional Director

Environmental Assessment and Major Projects Division
Ted Potter, Regional Manager
Ted Currie
Charlene Mathieu
Mark McLean

Habitat Management Division
Paul Boudreau, Regional Manager
Joe Crocker
Rick Devine
Joy Dubé
Beverley Grant
Anita Hamilton
Tony Henderson
Darren Hiltz
Carol Jacobi
Brian Jollymore
Darria Langill
Dave Longard
Jim Leadbetter
Melanie MacLean
Kurt McAllister
Shayne McQuaid
Andrew Newbould
Stacey Nurse
Marci Penney-Ferguson
Joanne Perry
Peter Rodger
Tammy Rose-Quinn
Carol Sampson
Janet Turner
Phil Zamora

Oceans and Coastal Management Division
Joe Arbour, Regional Manager
Heather Breeze
Scott Coffen-Smout
Penny Doherty
Dave Duggan
Derek Fenton
Jennifer Hackett
Glen Herbert
Tracy Horsman
Melanie Hurlburt
Stanley Johnston
Paul Macnab
Denise McCullough
Melissa McDonald
David Millar
Jason Naug
Daniel Walmsley
Maxine Westhead

Program Planning and Coordination Division
Tim Hall, Assistant Regional Director
Jane Avery
Debi Campbell
Carol Simmons

Aquaculture Management

Mark Cusack, Director
Darrell Harris
Cindy Webster
Sharon Young

Finance & Administration

Contract Services
Joan Hebert-Sellars

Material Services (Stores)
Larry MacDonald
Bob Page
Ray Rosse

Real Property Safety and Security Branch

Brian Thompson, Senior Site Leader

Term and casual employees, interns, students, and contractors are listed if they worked at BIO for at least four months in the year 2006.
+ Retired in 2006

Communications Branch

Art Cosgrove
Francis Kelly
Carl Myers
Norwood Whynot

Corporate Services

Valerie Bradshaw

Species at Risk Coordination Office
Diane Beanlands
Lynn Cullen
Arran McPherson
Kimberly Robichaud-LeBlanc
Heidi Schaefer

Planning and Information Services

Technology Services
Gary Somerton, Chief
Chris Archibald
Keith Bennett
Paulette Bertrand
Patrice Boivin
Phil Comeau
Bruce Fillmore
Judy Fredericks
Pamela Gardner
Lori Gauthier
Marc Hemphill
Charles Mason
Sue Paterson
Andrea Segovia
Mike Stepanczak
Paul Thom
Charlene Williams
Paddy Wong

Client Services
Sandra Gallagher, Chief
Jonathan Fleming
Ron Girard
Florence Hum
Adrienne LaRoche
Carol Levac
Dave MacDonald
Roeland Migchelsen
Juanita Pooley
Tobias Spears
Mike Van Wageningen
Bobbi Zahra

Library
Anna Frander, Chief
Rhonda Coll
Lori Collins
Lois Loewen
Maureen Martin
Marilynn Rudi
Diane Stewart

Records
Jim Martell, Supervisor
Myrtle Barkhouse
Carla Sears

NATURAL RESOURCES CANADA

Geological Survey Of Canada (Atlantic)

Director's Office
Jacob Verhoef, Director
Jennifer Bates
Pat Dennis
Carmelita Fisher
Don McAlpine*
Judith Ryan

Marine Resources Geoscience
Mike Avery
Ross Boutilier
Bob Courtney
Bernie Crilley
Claudia Currie
Maureen Cursley
Sonya Dehler
Kevin DesRoches
Rob Fensome
Peter Giles
Paul Girouard
Gary Grant
Evelyn Inglis
Ruth Jackson
Chris Jauer
Nelly Koziel
Paul Lake
Bill MacMillan
Anne Mazerall
Phil Moir
Gordon Oakey
Phil O'Regan
Russell Parrott
Stephen Perry
Patrick Potter
Matt Salisbury
John Shimeld
Phil Spencer
Barbara Szlavko
Frank Thomas
Hans Wielens
Graham Williams
Marie-Claude Williamson
Mark Williamson

Marine Environmental Geoscience
Ken Asprey
Anthony Atkinson
Marie Baker
Darrell Beaver
Robbie Bennett
Steve Blasco
Owen Brown
Gordon Cameron
Calvin Campbell
Borden Chapman
Mark Deptuck
Garret Duffy
Robert Fitzgerald
Donald Forbes
Paul Fraser
David Frobel
Michael Furlong
Iris Hardy
Robert Harmes
Scott Hayward
Thian Hundert
Sheila Hynes
Kate Jarrett
Kimberley Jenner
Fred Jodrey
Edward King
Vladimir Kostylev
Bill LeBlanc
Michael Li
Maureen MacDonald
Kevin MacKillop
Bill MacKinnon
Gavin Manson
Susan Merchant
Greg Middleton
Bob Miller
David Mosher
Bob Murphy
Kathryn Parlee
Michael Parsons
Eric Patton
Dick Pickrill
David Piper
Peter Pledge

Term and casual employees, interns, students, and contractors are listed if they worked at BIO for at least four months in the year 2006.
* Retired in 2006

Walta Rainey
Angus Robertson
John Shaw
Andy Sherin
Steve Solomon
Gary Sonnichsen
Bob Taylor
Brian Todd
Efthymios Tripsanas
Kevin Webb
Dustin Whalen
Bruce Wile

Shared Services Office
George McCormack, Manager
Cheryl Boyd
Terry Hayes
Cecilia Middleton
Julie Mills
Christine Myatt
Wayne Prime
Barb Vetese

PUBLIC WORKS AND GOVERNMENT SERVICES

Leo Lohnes, Property Manager
Tony Barkhouse
Tim Buckler
Bob Cameron
Geoff Gritten
Paul Fraser
Jim Frost
Garry MacNeill
John Miles
Arthurina Smardon
Phil Williams
Bill Wood

COMMISSIONAIRES

William Bewsher
Paul Bergeron
Dave Cyr
Marilyn Devost
Monique Doiron
Roger Doucet
John Dunlop
Donnie Hotte
Francis Noonan
Dave Smith
Don Smith
Daniel Wynn

CAFETERIA STAFF

Kelly Bezanson
Lynn Doubleday
Adele Schnare
Mark Vickers

OTHERS ON THE BIO CAMPUS

International Ocean-Colour Coordinating Group (IOCCG)

Venetia Stuart, Executive Scientist

Fishermen and Scientists Research Society (FSRS)

Jeff Graves
Cornelia den Heyer
Carl MacDonald
Shannon Scott-Tibbetts

Geoforce Consultants Ltd.

Dwight Reimer
Graham Standen
Martin Uyesugi

Contractors

Derek Broughton, Population Ecology
Catherine Budgell, Library
Melinda Cole, COOGER
Barbara Corbin, Records
Stephen Dickie, CHS
Ewa Dunlap, Coastal Ocean Science
Yongcun Hu, Ocean Circulation
Edward Kimball, Ocean Circulation
Xiaowei Ma, COOGER
Alan MacLean, CHS
Jeff Potvin, Informatics
Daniel Ricard, Population Ecology
Brian Robinson, Ocean Circulation
Ron Selinger, Records
Victor Soukhovtsev, Coastal Ocean Science
Jenny Tako, CHS
Patrick Upson, Ocean Physics
Tineke van der Baaren, Coastal Ocean Science
Tammy Waetcher, CHS
Rob Walters, CHS
Arthur Wickens, CHS
Alicia Williams, Population Ecology
Kari Workman, COOGER
Inna Yashayaev, Biological Oceanography

Scientist Emeritus/Science Alumnus

Piero Ascoli
Allyn Clarke
Ray Cranston
Subba Rao Durvasula
Jim Elliott
Gordon Fader
George Fowler
Donald Gordon
Alan Grant
Ralph Halliday
Lubomir Jansa
Brian Jessop
Charlotte Keen
Tim Lambert
René Lavoie
John Lazier
Mike Lewis
Doug Loring
David McKeown
Brian MacLean
Ken Mann
Clive Mason
Peta Mudie
Neil Oakey
Charlie Quon
Charlie Ross
Hal Sandstrom
Charles Schafer
Shiri Srivastava
James Stewart
John Wade

Recognition

BIO staff wish to recognize the contribution and support provided by the Captains and crews of Canadian Coast Guard vessels tasked to assist scientific research at BIO.

Term and casual employees, interns, students, and contractors are listed if they worked at BIO for at least four months in the year 2006.
* Retired in 2006

Retirements 2006

James Abriel retired from DFO after 33 years of service in marine chemistry at BIO. He began his career in 1974 with the Environmental Protection Service, undertaking activities such as freshwater quality testing, fish tissue biochemistry, and stable isotope analyses. He then became a radiochemical technician, taking measurements of a wide range of radionuclides in the Marine Radioactivity Section and serving as shipboard and field technician on numerous missions in support of the Point Lepreau Environmental Monitoring Program in the Bay of Fundy. Highlights of this program include the detection of airborne radioactive particulates and gases from the Chernobyl disaster in 1986. During his service with DFO, Jim served as a shipboard analyst, sampler, and sediment coring expert on many national and international missions, including three noteworthy Arctic missions. Most recently, he participated in two Davis Strait surveys aboard the MV *Knorr* (Woods Hole Oceanographic Institution) and the CCGS *Hudson* operating out of Nuuk, Greenland. His analytical skill in the laboratory and his vigorous sampling presence and execution at sea have been important elements in the success of DFO marine chemistry projects over the past three decades. Jim has enjoyed three trips to Italy and has been studying Italian, a pursuit that he plans to continue in retirement.

Michelle Brackett retired in December after 33.5 years in the Public Service of Canada. After graduating in 1972 from the Hôtel-Dieu School of Nursing in Campbellton, New Brunswick, she joined Health Canada (HC) in July 1973. Michelle worked at nursing stations in different Inuit communities in the Hudson Bay area. In 1978, she accepted a summer secondment to the Canadian Coast Guard (CCG) and sailed aboard the *John A. Macdonald* in the High Arctic. She so enjoyed this experience that she returned for several summers as a nurse aboard CCG vessels sailing out of the Dartmouth and Newfoundland regions. In 1980, Michelle transferred from the Ontario Region of HC to the naval dockyards in Halifax, where she provided occupational health nursing. In July 1981, she accepted the occupational health nursing position at BIO where she stayed until April 2001, when she moved to Halifax as Health Canada's National Coordinator for the CCG Health Officers Program. In April 2002, Michelle came back to BIO, accepting a transfer to DFO, CCG Central and Arctic Region, as their National Co-ordinator for CCG Health Officers Program, a position she occupied until her retirement. Michelle is looking forward to time with her family, travelling, and enjoying her holiday mobile home in Pictou County.

Margaret Burhoe retired from DFO's Ocean Sciences Division (OSD) after 26 years of public service. Meg was hired by DFO in 1988 and worked in several offices within the Science Branch. In 1998, she took an assignment with Operational Services of the Canadian Coast Guard, returning to her substantive position in January 2004. She retired from her position of secretary in the OSD manager's office in July.

Sharon Gillam-Locke retired from the OSD in July, after more than 35 years in the federal public service. She joined DFO's "typing pool" (word processing unit) in 1977, moved to the Ocean Circulation Section in 1987 as a secretary, and subsequently became the section's Administrative Officer. Her interpersonal and administrative skills were important to the operation and success of the section, particularly during times of limited budgets and changing management. Sharon made many wider contributions to BIO through volunteer work and generous help to others, including assistance in the gift shop where she is still active. The caring personal touch she brought to BIO resulted in many friendships that will continue beyond her departure from the Institute.

Barry T. Hargrave retired in December after working as a research scientist for 35 years. After completing his PhD in Zoology at the University of British Columbia and taking a postdoctoral fellowship in Denmark, Barry joined the Environmental Quality Division of the Marine Ecology Laboratory in 1971 as a benthic ecologist. Throughout his career, he conducted research to improve our basic knowledge of benthic-pelagic coupling, in particular, the flux of organic matter and oxygen between sediments and the water column. Over the years, Barry played a leadership role in numerous applied research programs such as the fate and effects of petroleum hydrocarbons, the ecological impacts of tidal power development in the Bay of Fundy, the potential effects of nuclear waste disposal in the deep sea, the long-range transport of atmospheric pollutants, and the ecological impacts of aquaculture. He worked closely with DFO engineers to develop new instruments for studying benthic processes.

Barry worked in a variety of environments including lakes, mudflats, coastal inlets, the continental shelf, canyons, the deep sea, and the Arctic. His research was of the highest quality and was well recognized in the international scientific community. He coauthored the popular text book, *Biological Oceanographic Processes*, and frequently served as a reviewer of manuscripts, programs, etc., and participated in national and international projects. Barry was very much a team player and gave freely of his time to help others. Throughout his career he maintained close contact with the university community and advised a large number of graduate students. He was also an excellent mentor for young scientists. Barry excelled at synthesizing research results and preparing sound scientific advice for DFO managers. He and his wife Margot have moved to Owen Sound, Ontario, where they live in their new home overlooking Georgian Bay.

Albert Hartling retired in June after 35 years of service with DFO. Bert started working at BIO in 1967 as an electronics technologist, but left to attend university in 1970. However, he continued at BIO as a

summer student until graduating with his Bachelor of Electrical Engineering degree in 1975, when he was hired as a project engineer. He completed his master's degree in the early 1980s. During his career with DFO, Bert accumulated extensive experience in the mobilization, operation, and maintenance of oceanographic instrumentation. More recently, he was a key member of the Technical Operations group where he was essential to ensuring the required instruments were operational, calibrated, and available for field programs at BIO and partner institutions. The success of our mooring program is due largely to his dedication, attention to detail, and expert design evaluation. BIO is to have continued access to Bert's expertise as he will be a Science Alumnus for the next two years.

Alex Herman retired from DFO's Ocean Physics Section on December 31, after 32 years at BIO. He started with the Metrology Division in 1974 and stayed with the group through changes of department, branch, and division, serving as Section Head for Ocean Physics from 1994 to 2001. Alex was very active in research programs that touched on many aspects of oceanography in the Atlantic, Arctic, and Pacific oceans. He developed instrumentation, led field programs to measure the growth of algae under the Arctic ice, and developed methods to measure snow cover on ice in the Gulf of St. Lawrence using helicopter-borne video cameras. He was involved in biological monitoring and holds patents for the Optical Plankton Counter and the Laser Optical Plankton Counter (LOPC), two instruments that have been successfully licensed to local industry. Alex won a Federal Partners in Technology Transfer Award for his work transferring this technology to private industry. He led the application of these sensors to various moored and towed platforms such the Batfish and Moving Vessel Profiler, increasing the collection of high resolution biological data by systems deployed behind vessels. Alex is recognized internationally as an expert in the field and has collaborated with many international researchers. Throughout his career, Alex has been a strong advocate of technology development within government laboratories to enable and facilitate the delivery of science programs: this has been of great benefit to BIO. In recent years, Alex has been working closely with researchers at Scripps Institution of Oceanography on LOPC use possibilities. He will continue his research as an Emeritus Scientist, sharing his time between BIO and Scripps.

Paul Keizer retired in December after 35 years with DFO. A Dartmouth native trained at Dalhousie as a physical chemist, in 1971 Paul joined the Environmental Quality Division in the Marine Ecology Laboratory where he became a key member of a team investigating the distribution, fate, and ecological effects of petroleum hydrocarbons in seawater and sediments. In the late 1970s, his research interests shifted to understanding the potential environmental effects of tidal power in the Bay of Fundy where he led numerous chemically oriented projects. He played a leading role in the synthesis of a wide range of physical, geological, chemical, and biological data and the development of a computer simulation model of the Cumberland Basin ecosystem. For several years, Paul made major contributions to programs dealing with the long-range transport of atmospheric pollutants and phycotoxins. In the late 1980s, after serving as the regional Aquaculture Coordinator, he began conducting research on the environmental impacts of aquaculture.

Throughout his career, Paul continually shifted his research to address high priority issues, developing an ability to synthesize information from a wide range of research areas into overarching ecological models. Perhaps it was this ability to see the big picture that led him into science management, where he had a major influence on integrating science with policy, locally and nationally. In 1995, he became Manager of the Habitat Ecology Division and a few years later, Manager of the newly created Marine Environmental Sciences Division where he effectively guided the Division through major reorganizations and resource cuts. In 2005, Paul stepped down as Division Manager to spend considerable time in Ottawa as a science advisor to the Director, Environmental Sciences Branch, and four months in 2006 as Acting Director. He is internationally recognized for his skills in team-building and finding ways to incorporate science into management decisions. As current Chair of the ICES (International Council for the Exploration of the Sea) Advisory Committee on the Marine Environment, Paul will continue to share his knowledge and spirit of community with the international marine science community.

Jim Leonard retired in October after 35 years at BIO, first with NRCAN, later with DFO. He participated in many and varied projects, including the presence of chemicals associated with harmful algal blooms, and over the past 10 years, the fate of toxic organic compounds in Halifax Harbour. For many years, Jim has maintained his own records of the daily temperature and kept track of weather around the world. He enjoys reading, talking about his children, and is a unique source of knowledge, as much historical as of current events. Jim was a valuable member of the Ecosystem Research Division organic laboratory staff.

Grant MacLeod retired in July, after 35 years of public service. He began his career in Ottawa as a summer student with the Department of Energy, Mines and Resources (EMR), drafting topographical maps of Labrador. After completing his education he joined the Canadian Hydrographic Service (CHS) in 1971, but returned to EMR in graphic design for the Energy Policy Sector. In 1978, Grant again moved to the CHS and relocated to BIO.

As well as producing many charts, he was involved in improving cartographic standards and was one of the first CHS employees to master digital mapping for production. He took part in surveys in Fortune Bay, and Ungava Bay, as well as revisory surveys of Nova Scotia, New Brunswick, and Prince Edward Island using GPS to confirm positions for paper chart and electronic navigation chart products. Grant considered his six-week exchange with the National Ocean Survey in Norfolk, Virginia in 1984 as one of the highlights of his career.

Grant is highly regarded for his ability to embrace new technology and invent ways of using new computer tools in the chart production process, where his extensive knowledge contributed to the transition to electronic navigational chart production and the new Hydrographic Product Database. He received an award for developing a time-saving drop-down menu for the CARIS GIS production system, was instrumental in researching and using recent satellite images on Google Earth to determine the currency of existing chart products, and, most recently led and mentored staff in the CHS Atlantic quality control project. Grant's colleagues will miss his dry humour, and hearing of his interests in cooking, music, and film.

Don McAlpine retired from the Geological Survey of Canada (GSC), Natural Resources Canada on May 31. Don joined GSC Atlantic in 1983 as a researcher with the Basin Analysis Group, now part of the Marine Resources Geoscience Subdivision. His work focused on petroleum geology offshore Atlantic Canada, with particular emphasis on the petroleum resources of the Jeanne d'Arc Basin and Grand Banks. In 1990, he published a major GSC paper on the Mesozoic stratigraphy, sediment evolution, and petroleum potential of the Jeanne d'Arc Basin, which introduced a new lithostratigraphic framework for this petroleum-rich region based on an integrated approach to basin analysis. Don became Manager of the Basin Analysis Group in 1990, and moved to the position of Manager, Research Development in the Director's Office in 2002. He added the duties of Head of the Marine Resources Geoscience Subdivision to his other management responsibilities in 2003.

John Moffatt retired in July, after a 35-year career with DFO. After graduating from the Nova Scotia Institute of Technology in 1971, he began working at BIO, where his dedicated service in technical support contributed greatly to oceanographic research. In 1992, John moved to the Halifax Fisheries Research laboratory where he worked on contaminant analysis until he returned to BIO in 1998. In the service of science, John travelled to the depths of the sea in a remotely operated vehicle, south to warmer climes including Bermuda, north to Iceland, and elsewhere, earning the respect and friendship of co-workers. His colleagues at BIO appreciated John's humour, good nature, and advice to "stop and smell the roses", and trust that in retirement he will be enjoying the "simple things in life" he espouses: spending time with his family, gardening, carving, and hunting and fishing at his cottage in Antigonish.

Ginette Robert retired in March. After graduating with a Ph.D. in Oceanography from Dalhousie University, in 1975 she joined the Molluscan Section of the Resource Development Branch of DFO to take charge of the soft-shell clam program, which included a trend-setting clam purification project. During 1978-81, she was in charge of the Ellerslie Biological Station in Prince Edward Island. Her work on cultivated mussel meat yields was used by industry and governments for years afterwards. In 1981, she redirected her efforts to scallops, responsible for both inshore and offshore stocks until 1989, when another scientist was charged with inshore stocks. Ginette held the offshore scallop mandate for 25 years. In her unassuming way, she acquired a deep understanding of scallop biology, ecology, and population dynamics. A strong believer in self-sufficiency, Ginette mastered the programs and models required for stock assessments, and devoted unusual effort to the completeness and accuracy of input data. Despite shrinking resources, relocations, and re-organization turmoil, she could be counted on to deliver quality scientific advice on time, every time.

Ginette understands the overlapping interests of DFO Science and Fisheries Management, and the operational needs of the private sector. Her natural ability to anticipate problems, coupled with superb communication and organizational skills have, over the years, avoided many problems and maintained valuable good will. Ginette's contribution has been widely recognized. In a 2001 comparative study, Yale University Professor Robert Repetto demonstrated the superiority of Canadian scallop management on Georges Bank over the American approach, and underlined the Canadian scientist's positive role in that successful fishery. In 2004, DFO granted her its highest distinction: the Deputy Minister's Prix d'Excellence. Her career has been one of selfless dedication to the well-being of the offshore scallop stocks, and to the livelihood of the fishermen depending on them. The result has been a sustained, prosperous fishery for a quarter-century, a record that she can justifiably be proud of, and a very hard act to follow.

Gary Rockwell joined the CHS in 1972, advancing to a Senior Assistant Hydrographer -in-Charge in 1978 and a Hydrographer-in-Charge in 1985. He served as a hydrographer or led projects on many vessels, participating in ship- and shore-based surveys throughout Atlantic Canada and the eastern Arctic until he "came ashore" in 1990. From 1991 to 1997 he held positions including Planning Officer; Manager, Data Management; and Training Officer for new recruits. From 1997 until his retirement, he was Division Manager responsible for coordinating the Data Acquisition activities of the CHS Atlantic.

Gary contributed to the implementation of major changes affecting at-sea positioning, data logging, and multibeam echo sounder system improvements. As national chair of the Data Acquisition and Analysis Committee, he was adept at acquiring capital funding, getting contracts in place, and taking delivery of equipment for the CHS across the country. His team also played a key role in broadening the application of hydrographic data outside the CHS's traditional Maritime Transportation mandate, demonstrating, with partners, that multibeam echo sounder data, when integrated with sediment and benthic sampling, could be used for benthic habitat classification. He also worked on the United Nations Convention on the Law of the Sea project. His final assignment was teaching at the 2006 hydrographic surveying course in Cornwall, Ontario. Gary contributed to the CHS to the very last day, literally walking out of the classroom on November 3 and flying home to retirement.

Doug Sameoto retired from DFO in October after 39 years as a Research Scientist at BIO, first with the Marine Ecology Lab, subsequently, the Biological Oceanography group in the Ocean Sciences Division, and, most recently, the Ecosystem Research Division. Doug is a distinguished, internationally recognized researcher and authority on the ecology of marine zooplankton, with more than 90 publications in scientific journals and DFO reports. He is perhaps best known for his contribution to the development and deployment of the BIONESS multiple opening and closing net system for sampling zooplankton and micro-nekton. The BIONESS enables scientists to more reliably collect the large forage plankton species and small fish that have been difficult to harvest with more conventional net systems. This sampling device, with some modifications, has been sold to ocean labs around the world.

Doug was also a major player in the development and interpretation of hydroacoustic data for assessing the presence and abundance of the larger macrozooplankton: his multi-decade acoustics surveys of krill in Emerald Basin represent a well-known and unique macrozooplankton time-series in the western North Atlantic. With his experience and extensive knowledge of long-term changes in plankton populations, Doug was a major voice in the development of DFO's

high profile Atlantic Zone Monitoring Program. For the last several years, he was the scientist in charge of the management, interpretation, and reporting of plankton conditions in the northwest Atlantic from the Continuous Plankton Recorder. Fortunately, Doug will be back at BIO as an Emeritus Scientist, continuing his unfinished research on the application of underwater acoustics to zooplankton ecology.

Nancy Stobo retired from the DFO Population Ecology Division in September, after 37 years. She began her career in 1970 at the Biological Station in St. Andrews, New Brunswick, first as secretary to the Pelagic Fish Group and later to the Station Director. In 1976, she transferred to BIO upon the establishment of a major component of the Marine Fish Division in the Halifax area. At that time, the group at BIO comprised six people; later it expanded to over 50. From 1980 to 2005, Nancy was the administrative assistant to a succession of Marine Fish Division managers. She was responsible for the purchasing activities, financial monitoring, and personnel functions of the BIO group, and for many years the personnel functions at St. Andrews. With the creation of the Population Ecology Division in 2005, Nancy continued in those roles, and the new division benefited greatly from her extensive experience and knowledge. Throughout her career, Nancy was a loyal, dedicated employee, whose prime interests were service to the division staff and the facilitation of good relations with corporate personnel and clients. Many of her activities were related to resolving unusual situations created by scientific staff unfamiliar with the accountability requirements of a large organization. Her office was the gathering place for staff to obtain information and help related to business, and a safe haven to discuss all manner of issues, both departmental and personal. Every division manager came to rely on her. We will all miss her expertise, professionalism, and friendship.

Peter Strain retired in June after a 32-year career as a Chemical Oceanographer. He progressed from a chemical technician to a research scientist and along the way made significant contributions to research on oxygen isotope ratios as chemical and physical oceanographic tracers, hydrocarbon pollution of intertidal waters, and, most recently, nutrient dynamics in inshore environments and problems related to eutrophication. Peter has settled in beautiful British Columbia.

Frank Zemlyak retired from DFO's Ocean Sciences Division in June, after more than 36 years in the Public Service of Canada. He joined the Chemical Oceanography Division at BIO in 1976 as a chemical technician, and was instrumental in the development and maintenance of a high quality measurement capability for carbon, chlorofluorocarbons, and other chemical ocean properties as part of DFO's ocean climate program. Frank participated in many field expeditions in the north Atlantic and Arctic oceans, on ice camps as well as vessels, often in harsh working conditions. His cheerful dedication and skill allowed BIO to make significant contributions to many internationally important research programs, and resulted in many valued friendships.

FINANCIAL RESOURCES

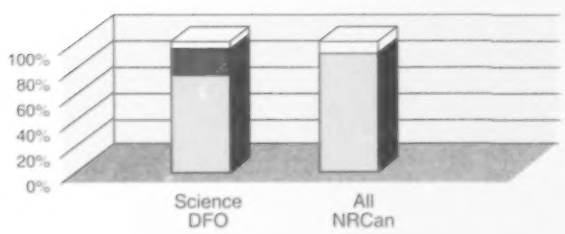
Where BIO obtains funding and how it is spent

Annual appropriation from government

DEPARTMENT	SECTOR	AMOUNT ($000)
DFO	Science	28,894
DFO	Oceans & Habitat	5,287
DFO	Informatics	4,210
NRCan	All	9,841

Environment Canada and DND have staff working at BIO. The resources used by those staff members are not captured in this report.

Other sources of funding

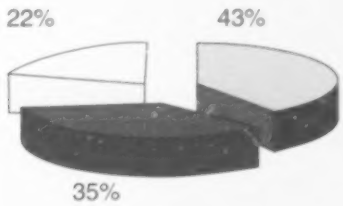


DEPARTMENT	SECTOR	GOVERNMENT ($000)	INSTITUTIONS ($000)	INDUSTRY ($000)
DFO	Science	6,568	2,555	637
NRCan	All	9,668		1,365

Industry Institutions Government

Program spending

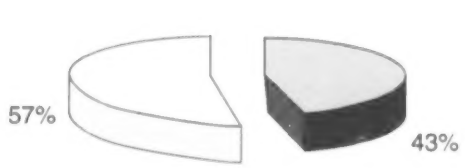
DFO Science



SECTOR	AMOUNT ($000)
Healthy and Productive Aquatic Ecosytems	16,329
Sustainable Fisheries and Aquaculture	13,636
Safe and Accessible Waterways	8,689

Program spending cont.

DFO Oceans and Habitat

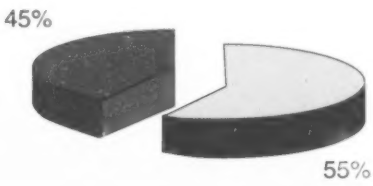


Habitat Managenent

Oceans

SECTOR	AMOUNT ($000)
Habitat Management	2,278
Oceans	3,009

NRCan

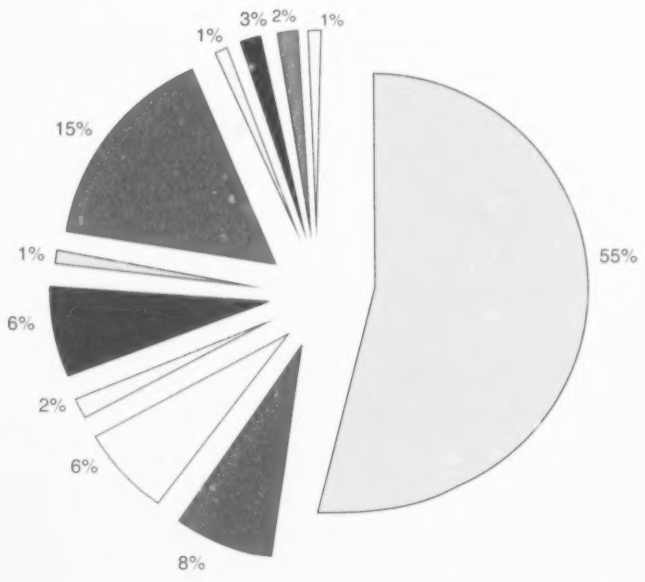


Research

Technology/Equip

	AMOUNT ($000)
Research	11,444
Technology/Equipment	9,430

BIO staff by Division/Department



DFO - Science	364
DFO - Oceans & Habitat	53
DFO - Informatics	37
DFO - Other	11
DFO - Coast Guard Tech Services	40
DFO - Aquaculture Coordination	4
NRCan - GSC Atlantic	104
EC - Operational Laboratories	4
DND - Survey Office	13
PWGSC - Site Operations	12
Research Coordination Units	3
Total	645

PUBLICATIONS AND PRODUCTS

Publications 2006

BEDFORD INSTITUTE OF OCEANOGRAPHY

SCIENTIFIC JOURNALS

DFO: Oceans and Habitat Branch

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Chart No. 4826. Burgeo to/ à François. (New chart)
Chart No. 4822. Cape St. John to/à St. Anthony. (New chart)
Chart No. 4864. Black Island to/à Little Denier Island. (New chart)
Chart No. 4911. Entrée à/Entrance to Miramichi River. (New edition)
Chart No. 4912. Miramichi. (New edition)
Chart No. 4114. Campobello Island. (New edition)

S57 ENCs (Electronic Navigational Charts) – 2006[1]

CA276652.	Chart 5024.	Nanaksaluk Island to/à Cape Kiglapait. (New chart)
CA376049.	Chart 5051.	Nunaksuk Island to/à Calf, Cow and/et Bull Islands. (New chart)
CA376050.	Chart 5052.	Seniartlit Islands to/à Nain. (New chart)
CA476069.	Chart 4233.	Whitehead Harbour. (New chart)
CA476600.	Chart 5070.	Akuliakatak Peninsula to/à Satosoak Island. (New chart)
CA476813.	Chart 4862.	Carmanville to/à Bacalhoa Island and/et Fogo. (New chart)
CA476814.	Chart 4862.	Carmanville to/à Bacalhoa Island and/et Fogo. (New chart)
CA576654.	Chart 5070.	Voisey Bay Wharf. (New chart)
CA176140.	Chart 4003.	Cape Breton to/à Cape Cod. (New edition)
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CA276101.	Chart 4049.	Grand Bank, Northern Portion. (New edition)

[1] Available from Nautical Data International Inc. (http://www.digitalocean.ca).

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CA276274.	Chart 4016.	Saint-Pierre to/à St. John's. (New edition)
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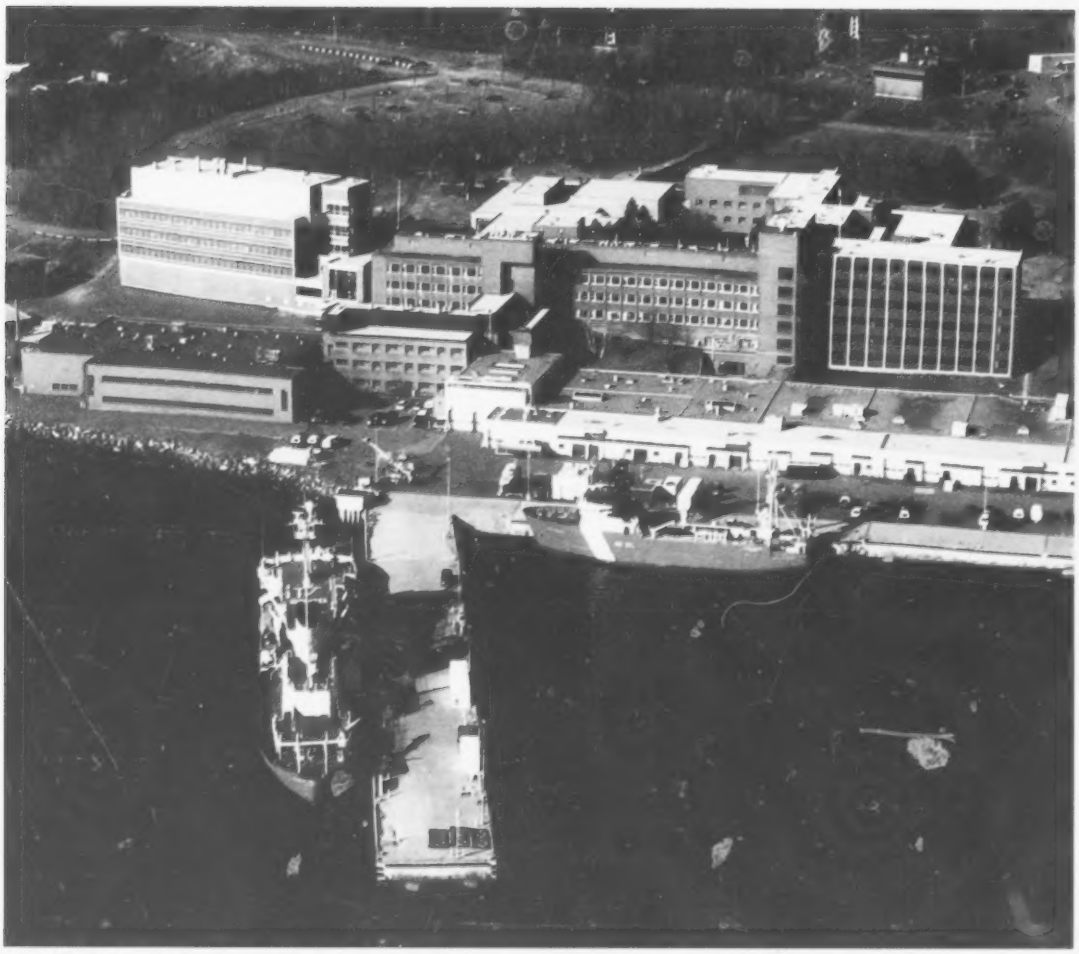
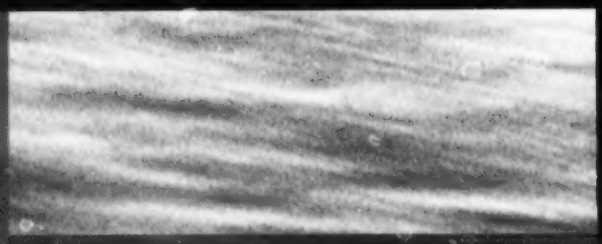
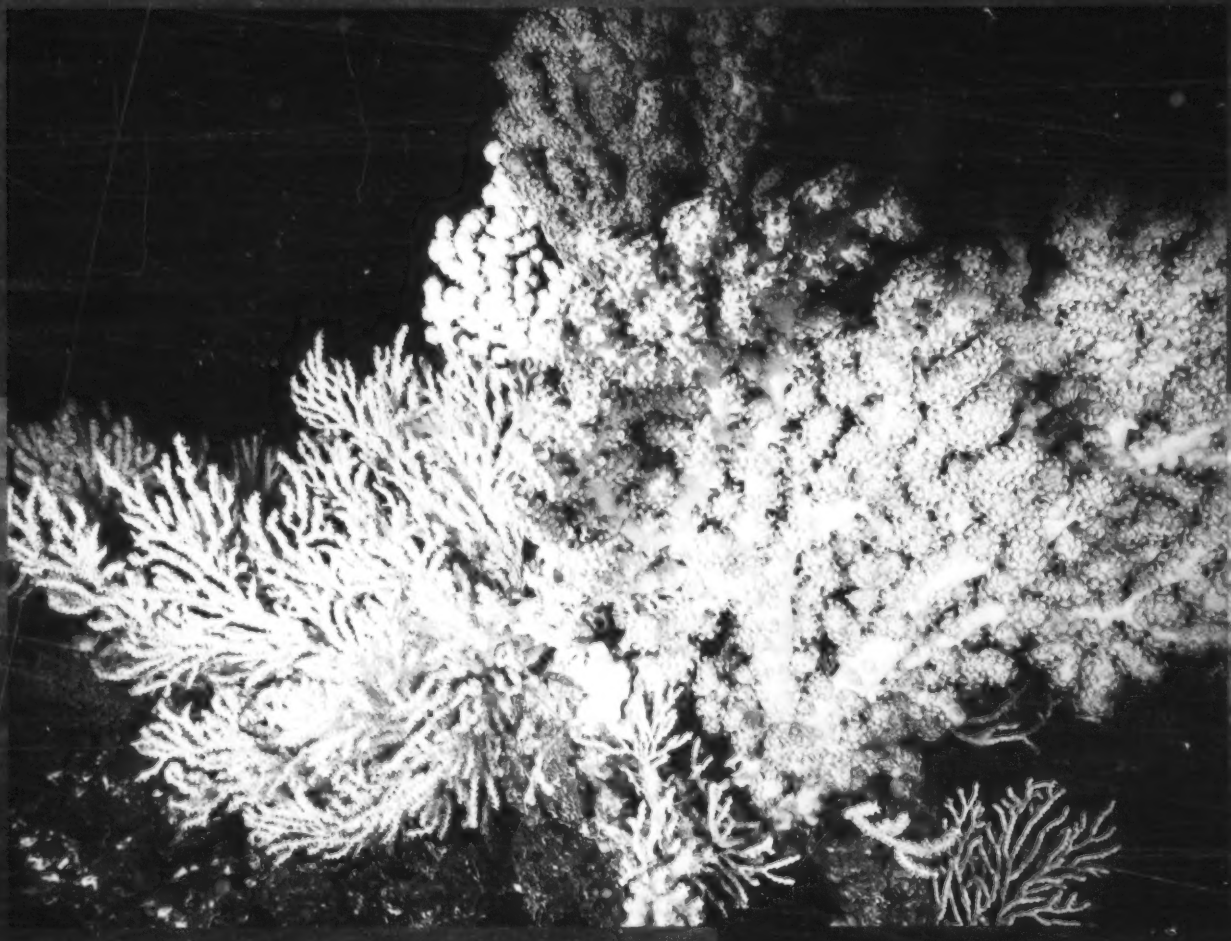


The Bedford Institute of Oceanography, photo by Jo-Ann Naugler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Natural Resources Canada	Ressources naturelles Canada
Environment Canada	Environnement Canada
National Defence	Défense nationale